ELECTROSTATIC COATING SYSTEM AND METHOD THEREFOR

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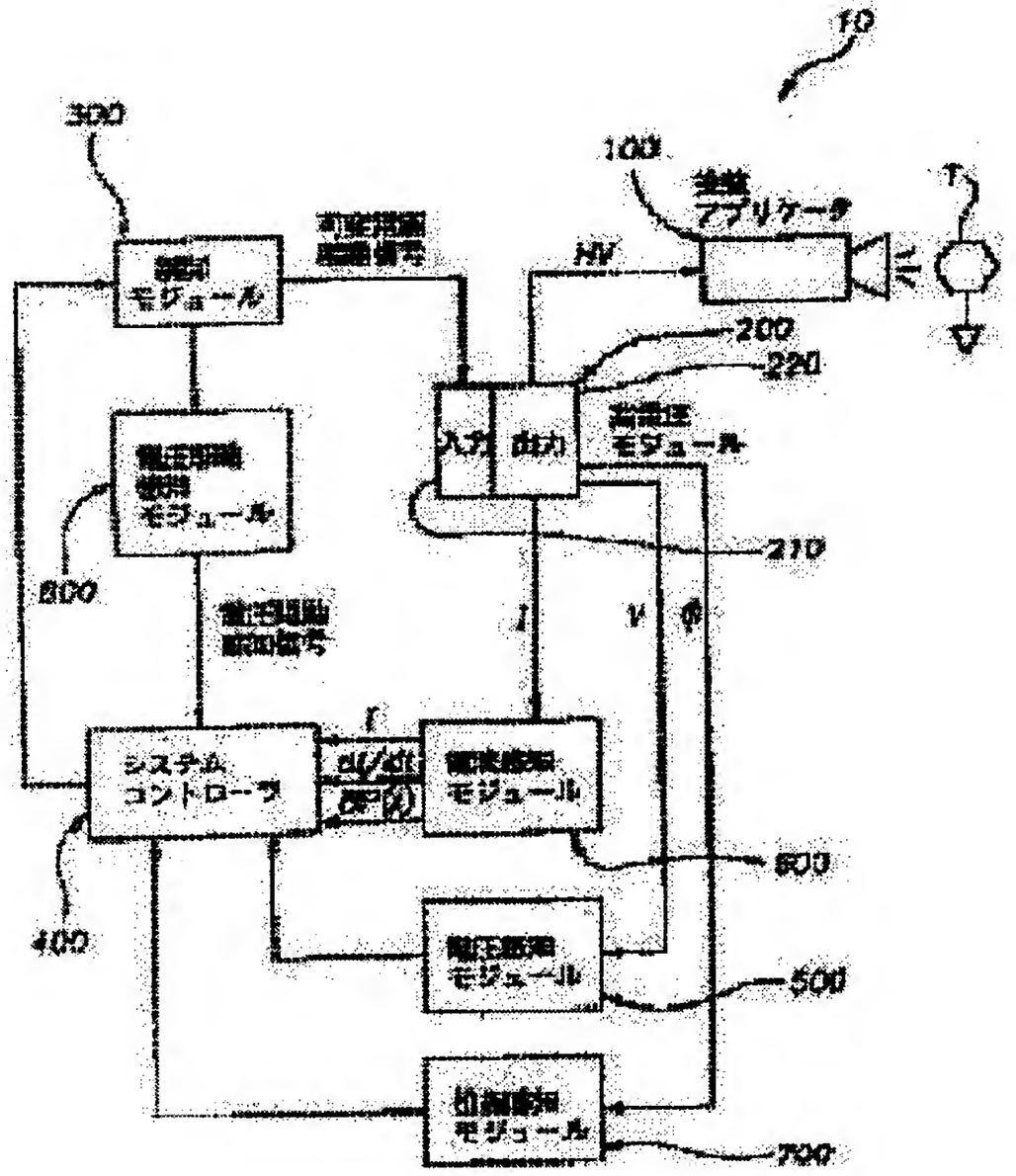
Abstract of **JP 10202151 (A)**
PROBLEM TO BE SOLVED: To prevent an electric discharge from being generated by a coating material applicator and at the same time, improve the efficiency of a high voltage power supply by controlling the increase and decrease of high voltage to be applied to the applicator based on a current sensing signal connected to an area between the applicator and a target object.
SOLUTION: When high voltage generated by connecting a variable voltage drive signal to a high voltage module 200 from a control module 300, is applied to a coating material applicator 100 for giving a coating material to a target object T, a current sensing signal which represents the current filtered within the range of a change rate of current or a zone passing frequency between the applicator 100 and the object T, is generated. Further, a control signal is connected to the control module 300 by a system controller 400 in response to the current sensing signal, so that the high voltage to be sent to the applicator 100 is decreased(increase) under control when the change rate of current increases(decreases).



* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1]High tension which is provided with the following and sent to the above-mentioned charge applicator of a finishing material, A current sensing signal showing at least one of the increases in current to which the filter of an increase in the above-mentioned current change rate and the above-mentioned band pass frequency range was carried out can be answered, and it can decrease with a control module, And high tension sent to the above-mentioned charge applicator of a finishing material, An electrostatic coating system for adhering a charge of a finishing material to a target object characterized by what a current sensing signal showing at least one of the reduction of current to which the filter of reduction of the above-mentioned current change rate and the above-mentioned band pass frequency range was carried out can be answered, and can be increased with a control module.
A charge applicator of a finishing material for turning to a target object a charge of a finishing material by which electrification was carried out, and giving it.
A high-tension module which has an input and an output and by which an output was connected to the above-mentioned charge applicator of a finishing material.
A control module which is a control module connected to an input of the above-mentioned high-tension module, and gives a variable voltage driving signal to an input of the above-mentioned high-tension module since high tension sent to the above-mentioned charge applicator of a finishing material is generated.
It is the current perception module connected to an output of the above-mentioned high-tension module, A rate of change of current between the above-mentioned charge applicator of a finishing material, and a target object, And a current perception module for generating a current sensing signal showing at least one of the current to which the filter of the band pass frequency range between the above-mentioned charge applicator of a finishing material and a target object was carried out, A system controller which was a system controller connected to the above-mentioned current perception module in order to receive a current sensing signal generated by the above-mentioned current perception module, and was connected to a control module in order to answer a current sensing signal and to give a control signal to a control module.

[Claim 2]A pulse width modulator which the above-mentioned control module is connected to the above-mentioned system controller, answers a control signal from the above-mentioned system controller, and generates a variable output signal, It is a switching regulator for being connected to the above-mentioned pulse width modulator, answering a variable output signal of the above-mentioned pulse width modulator, and generating a variable voltage driving signal, It is connected to an input of the above-mentioned high-tension module, have a switching regulator for giving a variable voltage driving signal to an input of the high-tension module, and the above-mentioned high-tension module, The system according to claim 1 which generates variable high tension which answers a variable voltage driving signal from the above-mentioned switching regulator, and is sent to the above-mentioned charge applicator of a finishing material.

[Claim 3]The above-mentioned high-tension module is provided with a transformer which has primary input winding and secondary output winding with a center tap, The above-mentioned center tap is connected to the above-mentioned control module, and the above-mentioned control module, Give a variable voltage driving signal to a center tap of the above-mentioned primary input winding, and the above-mentioned control module, Are the primacy phase driver connected to the 1st input of primary input winding of the above-mentioned transformer, and the 1st driving signal is answered, A primacy phase driver for carrying out the sink of the variable voltage driving signal sent to the above-mentioned center tap, Are the 2nd phase driver connected to the 2nd input of primary input winding of the above-mentioned transformer, and the 2nd driving signal is answered, Have further the 2nd phase driver for carrying out the sink of the variable voltage driving signal sent to the above-mentioned center tap, and the above-mentioned system controller, It is connected to the above-mentioned primacy phase driver and the 2nd phase driver, and and the above-mentioned system controller, The system according to claim 1 by which gave the 1st driving signal to a primacy phase driver, and the 2nd driving signal was given to the 2nd phase driver it and by turns, these 1st driving signal and 2nd driving signal are common drive frequencies, and about 180 degrees of phases have shifted.

[Claim 4]Since a phase sensing signal is generated, have further a phase perception module connected to an output of the above-mentioned high-tension module, and this phase perception module, It is connected to the system controller and in order to give a phase sensing signal to the above-mentioned system controller the above-mentioned system controller, The system according to claim 3 which adjusts drive frequency in resonance frequency of the above-mentioned high-tension module substantially by a certain phase shift, answers a phase sensing signal, and raises efficiency of a high-tension module.

[Claim 5]The system according to claim 3 by which this delay raises efficiency of the above-mentioned high-tension module including delay between those of the 1st driving signal and the 2nd driving signal.

[Claim 6]Since a voltage drive sensing signal is generated, have further a voltage drive perception module connected to a control module, and this voltage drive perception module, It is connected to the system controller and in order to give a voltage drive sensing signal to the above-mentioned system controller and the above-mentioned system controller, The system according to claim 3 to which drive frequency is changed in order to determine drive frequency in which a voltage drive sensing signal is answered and a variable voltage driving signal from a control module decreases.

[Claim 7]Since a voltage sensing signal is generated, have further a voltage sensing module connected to an output of the above-mentioned high-tension module, and this voltage sensing module, It is connected to the system controller and in order to give a voltage sensing signal to the above-mentioned system controller and the above-mentioned system controller, The system according to claim 1 which high tension which answers a voltage sensing signal, gives a control signal to the above-mentioned control module, and is sent to the above-mentioned charge applicator of a finishing material answers a voltage sensing signal given to the above-mentioned system controller, and can be adjusted to the 1st voltage level with the above-mentioned control module.

[Claim 8]The system according to claim 1 which are two or more charge applicators of a finishing material who the above-mentioned charge applicator of a finishing material turns to a target object a charge of a finishing material by which electrification was carried out, and give.

[Claim 9]The system according to claim 1 by which the above-mentioned high-tension module is provided with a universal winding type transformer connected to a voltage multiplier, and primary winding of this universal winding type transformer is connected to the above-mentioned control module, and an output of the above-mentioned voltage multiplier is connected to a charge applicator of a finishing material.

[Claim 10]A charge applicator of a finishing material for turning to a target object a charge of a finishing material by which electrification was carried out, and giving it in an electrostatic coating system for adhering a charge of a finishing material to a target object.

Primary input winding with a center tap, and a high-tension module output connected to the above-mentioned charge applicator of a finishing material.

Give the 1st driving signal to a primacy phase driver, and are the electrostatic coating system provided with the above, give the 2nd driving signal by turns to the 2nd phase driver, and the 1st driving signal and the 2nd driving signal, A system controller which is common drive frequency and is carrying out the phase gap about 180 degrees, It is the voltage drive perception module connected to the above-mentioned control module since a voltage drive sensing signal was generated, In order to give a voltage drive sensing signal to a system controller, have a voltage drive perception module connected to a system controller, and a variable voltage driving signal from the above-mentioned control module, One delay is given between the 1st driving signal and the 2nd driving signal, and by changing drive frequency, a voltage drive sensing signal is answered and it decreases.

[Claim 11]A rate of change of a direct current between the above-mentioned charge applicator of a finishing material, and a target object, and current between the above-mentioned charge applicator of a finishing material, and a target object, And since a current sensing signal showing at least one of the current to which the filter of the band pass frequency range between the above-mentioned charge applicator of a finishing material and a target object was carried out is generated, have further a current perception module connected to an output of the above-mentioned high-tension module, and the above-mentioned system controller, It is connected to a current perception module and in order to receive a current sensing signal generated by the above-mentioned current perception module and the above-mentioned system controller, High tension which is connected to the above-mentioned control module in order to answer a current sensing signal and to give a control signal to the above-mentioned control module, and is supplied to the above-mentioned charge applicator of a finishing material, A current sensing signal showing at least one of the increases in current to which the filter of an increase in the above-mentioned direct current, an increase in the above-mentioned current change rate, and the above-mentioned band pass frequency range was carried out can be answered, and it can decrease with a control module, High tension supplied to the above-mentioned charge applicator of a finishing material And reduction of the above-mentioned direct current, The system according to claim 10 which can answer a current sensing signal showing at least one of the reduction of current to which the filter of reduction of the above-mentioned current change rate and the above-mentioned band pass frequency range was carried out, and can increase with a control module.

[Claim 12]Since a phase sensing signal is generated, have further a phase perception module connected to an output of the above-mentioned high-tension module, and this phase perception module, It is connected to the system controller and in order to give a phase sensing signal to the above-mentioned system controller the above-mentioned system controller, The system according to claim 10 which adjusts drive frequency in resonance frequency of the above-mentioned high-tension module substantially by a certain phase shift, answers a phase sensing signal, and raises efficiency of a high-tension module.

[Claim 13]In a method for adhering a charge of a finishing material to a target object with an electrostatic coating system, A charge of a finishing material in which electrification was done towards a target object by charge applicator of a finishing material is given, High tension is supplied to the above-mentioned charge applicator of a finishing material with a high-tension module which has the output connected to the above-mentioned charge applicator of a finishing material, Give a variable voltage driving signal to an input of a high-tension module, and high tension is generated in an output of a high-tension module with a control module connected to an input of the high-tension module, With a current perception module connected to an output of a high-tension module, a rate-of-change signal of current between the above-mentioned charge applicator of a finishing material, and a target object, And a current sensing signal showing at least one of the current signals with which the filter of the band pass frequency range between the above-mentioned charge applicator of a finishing material and a target object was carried out is generated, High tension which answers a current sensing signal with a system controller connected to the above-mentioned current perception module and a control module, gives a control signal to a control module, and is supplied to the above-mentioned charge applicator of a finishing material, Answer a current sensing signal showing at least one of the increases in current to

which the filter of an increase in the above-mentioned current change rate and the above-mentioned band pass frequency range was carried out, and it decreases with the above-mentioned control module, And a method provided with a stage of answering a current sensing signal showing at least one of the reduction of current to which the filter of reduction of the above-mentioned current change rate and the above-mentioned band pass frequency range was carried out in high tension supplied to the above-mentioned charge applicator of a finishing material, and increasing with the above-mentioned control module.

[Claim 14]A current change rate exceeding a rate-of-change limit, And answer a current sensing signal to express for at least one of the current to which the filter of the band pass frequency range exceeding a band-pass filter current limit was carried out, and with the above-mentioned control module. A method according to claim 13 further provided with a stage of carrying out the disable of the high tension supplied to the above-mentioned charge applicator of a finishing material.

[Claim 15]High tension which answers a current sensing signal showing an increase in a direct current, and is supplied to a charge applicator of a finishing material with a control module is decreased, And a method according to claim 13 further provided with a stage of increasing high tension which answers a current sensing signal showing reduction in a direct current, and is supplied to a charge applicator of a finishing material with a control module.

[Claim 16]A method according to claim 15 further provided with a stage of carrying out the disable of the high tension which answers a current sensing signal showing a direct current exceeding a direct-current limit, and is supplied to a charge applicator of a finishing material with a control module.

[Claim 17]A direct current which increases high tension supplied to the above-mentioned charge applicator of a finishing material from the 1st direct-current level, A current change rate which increases from the 1st current change rate level, and a current sensing signal showing at least one of the current to which the filter of the band pass frequency range which increases from the 1st band pass current level was carried out are answered, Decrease with a control module lower than the 1st voltage level, and high tension supplied to the above-mentioned charge applicator of a finishing material, A direct current which decreases toward the 1st direct-current level, a current change rate which decreases toward the 1st current change rate level, And a method according to claim 13 further provided with a stage of answering a current sensing signal showing at least one of the current to which the filter of the band pass frequency range which decrease in number toward the 1st band pass current level was carried out, and increasing toward the 1st voltage level with a control module.

[Claim 18]A method comprising according to claim 13:

A primacy phase driver by whom the above-mentioned high-tension module was provided with a transformer which has primary input winding and secondary output winding with a center tap, the above-mentioned center tap was connected to the above-mentioned control module, and the above-mentioned control module was connected to the 1st input of primary input winding of the above-mentioned transformer.

Have further the 2nd phase driver connected to the 2nd input of primary input winding of the above-mentioned transformer, and the above-mentioned system controller, It is connected to the above-mentioned primacy phase driver and the 2nd phase driver, and a described method, A variable voltage driving signal is supplied to a center tap of primary input winding of the above-mentioned transformer, Give the 1st driving signal to the above-mentioned primacy phase driver, and give the 2nd driving signal to the above-mentioned 2nd phase driver it and by turns, and these 1st driving signals and the 2nd driving signal, The sink of the variable voltage driving signal which it is common drive frequency, and about 180 degrees of phases have shifted, answers the 1st driving signal from the above-mentioned primacy phase driver, and is supplied to the above-mentioned center tap is carried out, And a stage of carrying out the sink of the variable voltage driving signal which answers the 2nd driving signal from the above-mentioned 2nd phase driver, and is supplied to the above-mentioned center tap by turns.

[Claim 19]A phase sensing signal is generated with a phase perception module connected to an output of the above-mentioned high-tension module, Supply the above-mentioned phase sensing signal to a

system controller, and the above-mentioned phase perception module is connected to a system controller, And a method according to claim 18 further provided with a stage of adjusting drive frequency in resonance frequency of a high-tension module substantially by a certain phase shift, answering the above-mentioned phase sensing signal, and raising efficiency of a high-tension module.
[Claim 20]A method according to claim 18 of giving delay and raising efficiency of a high-tension module between the 1st driving signal and the 2nd driving signal.
[Claim 21]A voltage drive sensing signal is generated with a voltage drive perception module connected to the above-mentioned control module, Supply the above-mentioned voltage drive sensing signal to a system controller, and the above-mentioned voltage drive perception module, A method according to claim 18 provided with a stage of changing drive frequency so that the above-mentioned voltage drive sensing signal may be answered and a variable voltage driving signal from a control module may be decreased, by being connected to a system controller.
[Claim 22]Generate a voltage sensing signal with a voltage sensing module connected to an output of the above-mentioned high-tension module, supply the above-mentioned voltage sensing signal to a system controller, and the above-mentioned voltage sensing module, A method according to claim 18 which was connected to a system controller and provided with a stage of answering the above-mentioned voltage sensing signal, giving a control signal to a control module, and adjusting high tension of the above-mentioned charge applicator of a finishing material to the 1st voltage level.

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1]High tension which is provided with the following and sent to the above-mentioned charge applicator of a finishing material, A current sensing signal showing at least one of the increases in current to which the filter of an increase in the above-mentioned current change rate and the above-mentioned band pass frequency range was carried out can be answered, and it can decrease with a control module, And high tension sent to the above-mentioned charge applicator of a finishing material, An electrostatic coating system for adhering a charge of a finishing material to a target object characterized by what a current sensing signal showing at least one of the reduction of current to which the filter of reduction of the above-mentioned current change rate and the above-mentioned band pass frequency range was carried out can be answered, and can be increased with a control module.
A charge applicator of a finishing material for turning to a target object a charge of a finishing material by which electrification was carried out, and giving it.
A high-tension module which has an input and an output and by which an output was connected to the above-mentioned charge applicator of a finishing material.
A control module which is a control module connected to an input of the above-mentioned high-tension module, and gives a variable voltage driving signal to an input of the above-mentioned high-tension module since high tension sent to the above-mentioned charge applicator of a finishing material is generated.
It is the current perception module connected to an output of the above-mentioned high-tension module, A rate of change of current between the above-mentioned charge applicator of a finishing material, and a target object, And a current perception module for generating a current sensing signal showing at least one of the current to which the filter of the band pass frequency range between the above-mentioned charge applicator of a finishing material and a target object was carried out, A system controller which was a system controller connected to the above-mentioned current perception module in order to receive a current sensing signal generated by the above-mentioned current perception module, and was connected to a control module in order to answer a current sensing signal and to give a control signal to a control module.

[Claim 2]A pulse width modulator which the above-mentioned control module is connected to the above-mentioned system controller, answers a control signal from the above-mentioned system controller, and generates a variable output signal, It is a switching regulator for being connected to the above-mentioned pulse width modulator, answering a variable output signal of the above-mentioned pulse width modulator, and generating a variable voltage driving signal, It is connected to an input of the above-mentioned high-tension module, have a switching regulator for giving a variable voltage driving signal to an input of the high-tension module, and the above-mentioned high-tension module, The system according to claim 1 which generates variable high tension which answers a variable voltage driving signal from the above-mentioned switching regulator, and is sent to the above-mentioned charge applicator of a finishing material.

[Claim 3]The above-mentioned high-tension module is provided with a transformer which has primary input winding and secondary output winding with a center tap, The above-mentioned center tap is connected to the above-mentioned control module, and the above-mentioned control module, Give a variable voltage driving signal to a center tap of the above-mentioned primary input winding, and the above-mentioned control module, Are the primacy phase driver connected to the 1st input of primary input winding of the above-mentioned transformer, and the 1st driving signal is answered, A primacy phase driver for carrying out the sink of the variable voltage driving signal sent to the above-mentioned center tap, Are the 2nd phase driver connected to the 2nd input of primary input winding of the above-mentioned transformer, and the 2nd driving signal is answered, Have further the 2nd phase driver for carrying out the sink of the variable voltage driving signal sent to the above-mentioned center tap, and the above-mentioned system controller, It is connected to the above-mentioned primacy phase driver and the 2nd phase driver, and and the above-mentioned system controller, The system according to claim 1 by which gave the 1st driving signal to a primacy phase driver, and the 2nd driving signal was given to the 2nd phase driver it and by turns, these 1st driving signal and 2nd driving signal are common drive frequencies, and about 180 degrees of phases have shifted.

[Claim 4]Since a phase sensing signal is generated, have further a phase perception module connected to an output of the above-mentioned high-tension module, and this phase perception module, It is connected to the system controller and in order to give a phase sensing signal to the above-mentioned system controller the above-mentioned system controller, The system according to claim 3 which adjusts drive frequency in resonance frequency of the above-mentioned high-tension module substantially by a certain phase shift, answers a phase sensing signal, and raises efficiency of a high-tension module.

[Claim 5]The system according to claim 3 by which this delay raises efficiency of the above-mentioned high-tension module including delay between those of the 1st driving signal and the 2nd driving signal.

[Claim 6]Since a voltage drive sensing signal is generated, have further a voltage drive perception module connected to a control module, and this voltage drive perception module, It is connected to the system controller and in order to give a voltage drive sensing signal to the above-mentioned system controller and the above-mentioned system controller, The system according to claim 3 to which drive frequency is changed in order to determine drive frequency in which a voltage drive sensing signal is answered and a variable voltage driving signal from a control module decreases.

[Claim 7]Since a voltage sensing signal is generated, have further a voltage sensing module connected to an output of the above-mentioned high-tension module, and this voltage sensing module, It is connected to the system controller and in order to give a voltage sensing signal to the above-mentioned system controller and the above-mentioned system controller, The system according to claim 1 which high tension which answers a voltage sensing signal, gives a control signal to the above-mentioned control module, and is sent to the above-mentioned charge applicator of a finishing material answers a voltage sensing signal given to the above-mentioned system controller, and can be adjusted to the 1st voltage level with the above-mentioned control module.

[Claim 8]The system according to claim 1 which are two or more charge applicators of a finishing material who the above-mentioned charge applicator of a finishing material turns to a target object a charge of a finishing material by which electrification was carried out, and give.

[Claim 9]The system according to claim 1 by which the above-mentioned high-tension module is provided with a universal winding type transformer connected to a voltage multiplier, and primary winding of this universal winding type transformer is connected to the above-mentioned control module, and an output of the above-mentioned voltage multiplier is connected to a charge applicator of a finishing material.

[Claim 10]A charge applicator of a finishing material for turning to a target object a charge of a finishing material by which electrification was carried out, and giving it in an electrostatic coating system for adhering a charge of a finishing material to a target object.

Primary input winding with a center tap, and a high-tension module output connected to the above-mentioned charge applicator of a finishing material.

Give the 1st driving signal to a primacy phase driver, and are the electrostatic coating system provided with the above, give the 2nd driving signal by turns to the 2nd phase driver, and the 1st driving signal and the 2nd driving signal, A system controller which is common drive frequency and is carrying out the phase gap about 180 degrees, It is the voltage drive perception module connected to the above-mentioned control module since a voltage drive sensing signal was generated, In order to give a voltage drive sensing signal to a system controller, have a voltage drive perception module connected to a system controller, and a variable voltage driving signal from the above-mentioned control module, One delay is given between the 1st driving signal and the 2nd driving signal, and by changing drive frequency, a voltage drive sensing signal is answered and it decreases.

[Claim 11]A rate of change of a direct current between the above-mentioned charge applicator of a finishing material, and a target object, and current between the above-mentioned charge applicator of a finishing material, and a target object, And since a current sensing signal showing at least one of the current to which the filter of the band pass frequency range between the above-mentioned charge applicator of a finishing material and a target object was carried out is generated, have further a current perception module connected to an output of the above-mentioned high-tension module, and the above-mentioned system controller, It is connected to a current perception module and in order to receive a current sensing signal generated by the above-mentioned current perception module and the above-mentioned system controller, High tension which is connected to the above-mentioned control module in order to answer a current sensing signal and to give a control signal to the above-mentioned control module, and is supplied to the above-mentioned charge applicator of a finishing material, A current sensing signal showing at least one of the increases in current to which the filter of an increase in the above-mentioned direct current, an increase in the above-mentioned current change rate, and the above-mentioned band pass frequency range was carried out can be answered, and it can decrease with a control module, High tension supplied to the above-mentioned charge applicator of a finishing material And reduction of the above-mentioned direct current, The system according to claim 10 which can answer a current sensing signal showing at least one of the reduction of current to which the filter of reduction of the above-mentioned current change rate and the above-mentioned band pass frequency range was carried out, and can increase with a control module.

[Claim 12]Since a phase sensing signal is generated, have further a phase perception module connected to an output of the above-mentioned high-tension module, and this phase perception module, It is connected to the system controller and in order to give a phase sensing signal to the above-mentioned system controller the above-mentioned system controller, The system according to claim 10 which adjusts drive frequency in resonance frequency of the above-mentioned high-tension module substantially by a certain phase shift, answers a phase sensing signal, and raises efficiency of a high-tension module.

[Claim 13]In a method for adhering a charge of a finishing material to a target object with an electrostatic coating system, A charge of a finishing material in which electrification was done towards a target object by charge applicator of a finishing material is given, High tension is supplied to the above-mentioned charge applicator of a finishing material with a high-tension module which has the output connected to the above-mentioned charge applicator of a finishing material, Give a variable voltage driving signal to an input of a high-tension module, and high tension is generated in an output of a high-tension module with a control module connected to an input of the high-tension module, With a current perception module connected to an output of a high-tension module, a rate-of-change signal of current between the above-mentioned charge applicator of a finishing material, and a target object, And a current sensing signal showing at least one of the current signals with which the filter of the band pass frequency range between the above-mentioned charge applicator of a finishing material and a target object was carried out is generated, High tension which answers a current sensing signal with a system controller connected to the above-mentioned current perception module and a control module, gives a control signal to a control module, and is supplied to the above-mentioned charge applicator of a finishing material, Answer a current sensing signal showing at least one of the increases in current to

which the filter of an increase in the above-mentioned current change rate and the above-mentioned band pass frequency range was carried out, and it decreases with the above-mentioned control module, And a method provided with a stage of answering a current sensing signal showing at least one of the reduction of current to which the filter of reduction of the above-mentioned current change rate and the above-mentioned band pass frequency range was carried out in high tension supplied to the above-mentioned charge applicator of a finishing material, and increasing with the above-mentioned control module.

[Claim 14]A current change rate exceeding a rate-of-change limit, And answer a current sensing signal to express for at least one of the current to which the filter of the band pass frequency range exceeding a band-pass filter current limit was carried out, and with the above-mentioned control module. A method according to claim 13 further provided with a stage of carrying out the disable of the high tension supplied to the above-mentioned charge applicator of a finishing material.

[Claim 15]High tension which answers a current sensing signal showing an increase in a direct current, and is supplied to a charge applicator of a finishing material with a control module is decreased, And a method according to claim 13 further provided with a stage of increasing high tension which answers a current sensing signal showing reduction in a direct current, and is supplied to a charge applicator of a finishing material with a control module.

[Claim 16]A method according to claim 15 further provided with a stage of carrying out the disable of the high tension which answers a current sensing signal showing a direct current exceeding a direct-current limit, and is supplied to a charge applicator of a finishing material with a control module.

[Claim 17]A direct current which increases high tension supplied to the above-mentioned charge applicator of a finishing material from the 1st direct-current level, A current change rate which increases from the 1st current change rate level, and a current sensing signal showing at least one of the current to which the filter of the band pass frequency range which increases from the 1st band pass current level was carried out are answered, Decrease with a control module lower than the 1st voltage level, and high tension supplied to the above-mentioned charge applicator of a finishing material, A direct current which decreases toward the 1st direct-current level, a current change rate which decreases toward the 1st current change rate level, And a method according to claim 13 further provided with a stage of answering a current sensing signal showing at least one of the current to which the filter of the band pass frequency range which decrease in number toward the 1st band pass current level was carried out, and increasing toward the 1st voltage level with a control module.

[Claim 18]A method comprising according to claim 13:

A primacy phase driver by whom the above-mentioned high-tension module was provided with a transformer which has primary input winding and secondary output winding with a center tap, the above-mentioned center tap was connected to the above-mentioned control module, and the above-mentioned control module was connected to the 1st input of primary input winding of the above-mentioned transformer.

Have further the 2nd phase driver connected to the 2nd input of primary input winding of the above-mentioned transformer, and the above-mentioned system controller, It is connected to the above-mentioned primacy phase driver and the 2nd phase driver, and a described method, A variable voltage driving signal is supplied to a center tap of primary input winding of the above-mentioned transformer, Give the 1st driving signal to the above-mentioned primacy phase driver, and give the 2nd driving signal to the above-mentioned 2nd phase driver it and by turns, and these 1st driving signals and the 2nd driving signal, The sink of the variable voltage driving signal which it is common drive frequency, and about 180 degrees of phases have shifted, answers the 1st driving signal from the above-mentioned primacy phase driver, and is supplied to the above-mentioned center tap is carried out, And a stage of carrying out the sink of the variable voltage driving signal which answers the 2nd driving signal from the above-mentioned 2nd phase driver, and is supplied to the above-mentioned center tap by turns.

[Claim 19]A phase sensing signal is generated with a phase perception module connected to an output of the above-mentioned high-tension module, Supply the above-mentioned phase sensing signal to a

system controller, and the above-mentioned phase perception module is connected to a system controller, And a method according to claim 18 further provided with a stage of adjusting drive frequency in resonance frequency of a high-tension module substantially by a certain phase shift, answering the above-mentioned phase sensing signal, and raising efficiency of a high-tension module.
[Claim 20]A method according to claim 18 of giving delay and raising efficiency of a high-tension module between the 1st driving signal and the 2nd driving signal.
[Claim 21]A voltage drive sensing signal is generated with a voltage drive perception module connected to the above-mentioned control module, Supply the above-mentioned voltage drive sensing signal to a system controller, and the above-mentioned voltage drive perception module, A method according to claim 18 provided with a stage of changing drive frequency so that the above-mentioned voltage drive sensing signal may be answered and a variable voltage driving signal from a control module may be decreased, by being connected to a system controller.
[Claim 22]Generate a voltage sensing signal with a voltage sensing module connected to an output of the above-mentioned high-tension module, supply the above-mentioned voltage sensing signal to a system controller, and the above-mentioned voltage sensing module, A method according to claim 18 which was connected to a system controller and provided with a stage of answering the above-mentioned voltage sensing signal, giving a control signal to a control module, and adjusting high tension of the above-mentioned charge applicator of a finishing material to the 1st voltage level.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the electrostatic coating system and method of adhering the charge of a finishing material to a target object, and relates to preventing the discharge from the charge applicator of a finishing material of an electrostatic coating system in details, and raising more, the efficiency of the high voltage power which supplies high tension to the charge applicator of a finishing material of an electrostatic coating system to them.
[0002]
[Description of the Prior Art]An electrostatic coating system gives the charge of a finishing material of a fluid or a granular material by which electrification was electrostatically carried out to the target object which is standing it still or is moved along with a conveyor, and is used for adhering the charge of a finishing material to a target object uniformly substantially. Generally these systems are provided with the charge applicator of a finishing material maintained by high potential to the target object. Although this charge applicator of a finishing material always is not so, he is usually electronegative potential. And a target object is maintained earth potentials or near the.
The term of the charge applicator of a finishing material who uses it here carries out electrification Perilla frutescens (L.) Britton var. crispa (Thunb.) Decne. of the charge of a finishing material of a granular material and a fluid, and points out the device of a certain kind for turning to a target object the charge of a finishing material by which electrification was carried out, and giving it. These charge applicators of a finishing material for example, As reference. United States patent 5th entitled "non incendive rotary-atomizer (Nonincendive Rotary Atomizer)" as of [of Mr. Howe transferred to Lance Berg Corporation which is a grantee of this invention taken up here] July 18, 1995, As indicated by No. 433,387, it divides and the charge grant cancer of a finishing material, the charge grant bell of a finishing material, and the charge grant spray pump of a finishing material are included.
[0003]The comparatively high voltage between the charge applicator of a finishing material and a target object causes the danger of the substantial electric shock to an operator with the potential of the discharge produced between the charge applicator of a finishing material, and a target object including an operator, or a spark. Since many charges of a finishing material are volatility and an inflammability, if discharge arises, they will light and also cause the danger of injury. When operating an electrostatic coating system, it is applied by the workplace safety code based on an OKYUPESHON safety and health act (OSHA), and a liability insurance contractor, It is required that operation of electrostatic coating should agree to the National fire protection association (NFPA) standard about spraying finishing work, and should be performed except for some. Therefore, by agreeing in a government bye law and engineering specification, in order to decrease fear of the injury to an operator, to prevent discharge of an electrostatic coating system is desired.
[0004]
[Problem(s) to be Solved by the Invention]Some progress is already seen toward reduction of fear of discharge of an electrostatic coating system. For example, in U.S. Pat. No. 4,187,527 entitled "the

electrostatic coating system (Electrostatic Coating System)" as of [of Mr. Bentley transferred to Lance Berg Corporation which is a grantee of this invention] February 5, 1980, The electrical shorting devices which have discharging resistance with low resistance decrease in number promptly the high tension between the charge applicator of a finishing material, and a target object to zero, when a spark state approaches. More, this discharge device answers that current superfluous between the charge applicator of a finishing material and a target object or a superfluous current change rate is detected, and is enabled by details by a control circuit. Generally it depends for these current parameters detected on the distance between the charge applicator of a finishing material, and a target object, the size of a target object, shape, and the rate that a target object moves to the charge applicator of a finishing material. Therefore, Mr. Bentley prevents discharge by carrying out the disable of the voltage of the charge applicator of a finishing material rapidly, when electric sparks approach. However, Mr. Bentley answers the changing current parameter and he does not change the voltage of the charge applicator of a finishing material. Rather, only when the high tension of Mr. Bentley's charge applicator of a finishing material crosses the limit of a current parameter, the changing influence of a current parameter is received, then, the disable of the voltage is carried out thoroughly and it must be reset manually.

[0005]U.S. Pat. No. 4,745,520 which also entitles this "the power supply (Power Supply)" as of [of Mr. Fuzee transferred to Lance Berg Corporation which is a grantee of this invention] May 17, 1988, The electrostatic coating system which has the high voltage generator connected to the charge applicator of a finishing material is indicated. The high tension of the charge applicator of a finishing material is discharged comparatively promptly by removing substantially the high resistance and the high capacitance of generating high voltage and the charge applicator of a finishing material, when an electric spark approaches. A high voltage generator is provided with a high-tension transformer, that primary winding by which the center tap was carried out is driven with the driving signal of pulse width abnormal conditions, and this driving signal is switched by turns through two half-portions of primary winding under control of a fixed frequency oscillator. The driving signal of pulse width abnormal conditions answers a control signal, and adjusts the high tension of the charge applicator of a finishing material based on a voltage feedback signal. The disable of the high voltage generator is carried out by discharging the high tension of the charge applicator of a finishing material through a series of resistance by answering the overload current detected between the charge applicator of a finishing material, and the target object, and removing voltage from the center tap of primary winding. However, Mr. Fuzee's system must be manually reset, when an overload current state is answered and the disable of the high voltage generator is carried out. Although the signal showing corona discharge is answered and a disable is carried out momentarily, a high voltage generator is enabled only when generating of the signal showing corona discharge becomes discontinuous in a specific time period. Mr. Fuzee's system must be manually reset like the case of an overload current state except it. Mr. Fuzee also answers the changing current parameter and he does not change the voltage of the charge applicator of a finishing material. Rather, like Mr. Bentley, only when the limit of a current parameter is crossed, the disable of the high tension of Mr. Fuzee's charge applicator of a finishing material is carried out thoroughly. Mr. Fuzee gives automatic system recovery, when a current defect is amended in the appointed time period, otherwise a system must be reset manually.

[0006]Rans-Pak(registered trademark) 1000 power supply which can be obtained from the State of Indiana and Landsberg Corporation of Indianapolis is provided with a high-tension transformer and an one cascade transformer, and supplies generating high voltage to the charge applicator of a finishing material. The high tension of the charge applicator of a finishing material is controlled based on many current parameters between the charge applicator of a finishing material, and a target object. The high tension of the charge applicator of a finishing material answers a direct-current overloaded state the same with having described above about Mr. Fuzee's U.S. Pat. No. 4,745,520, and a disable is carried out to the 1st. High tension changes [2nd] dynamically as direct-current change between a direct-current threshold and the direct-current value corresponding to a direct-current overloaded state. When a target object approaches the charge applicator of a finishing material, high tension answers an increasing direct current and decreases along the load line of a steep slope, and when a target object separates from

the charge applicator of a finishing material, voltage answers a direct current which decreases and it is increased along the load line of the same steep slope. However, according to this composition, voltage is controlled by the load line of a steep slope over direct-current change of the comparatively narrow range. Rans-Pak(registered trademark) 1000 power supply does not include the dynamic voltage control which answers the current parameter showing change and corona discharge of a current change rate. Therefore, Rans-Pak(registered trademark) 1000 power supply will receive the disable operation with unnecessary high tension of the charge applicator of a finishing material, in order to prevent discharge.
[0007]October 27, 1992 attachment of Mr. Fuzee transferred to Lance Berg Corporation this [whose] is also a grantee of this invention "high-voltage-power control system (High Voltage Power Supply Control.) U.S. Pat. No. 5,159,544 entitled System", It has the charge applicator of a finishing material connected to the high voltage generator containing a high-tension transformer, and the above-mentioned high voltage generator operates with the resonance frequency, and gives maximum output voltage, and an electrostatic coating system which decrease in number fear of discharge is indicated. A voltage controlled oscillator gives the output signal for driving the primary winding of a high-tension transformer. A phase comparator generates a control signal based on the output phase of an output signal of a voltage controlled oscillator, and the output phase of an output signal of the secondary winding of a high-tension transformer. The control signal of a phase comparator is used for changing the frequency of the output signal generated by the voltage controlled oscillator, and it is made for a 90-degree phase shift to produce it to the output signal of the secondary winding of a high-tension transformer. Therefore, the high-tension transformer operates with the maximum output voltage, and prevents fear of the unexpected voltage serge which produces discharge.
[0008]It is clear from the above explanation that there is the necessity of dividing and improving a publicly known electrostatic coating system and a method for the same.
[0009]
[Means for Solving the Problem]So, the purpose of this invention is to provide a new electrostatic coating system and a method of conquering a publicly known problem. The purpose of this invention is to provide a new electrostatic coating system and a method of decreasing fear of discharge between a charge applicator of a finishing material, and a target object.
[0010]Another purpose of this invention adjusts dynamically voltage supplied to a charge applicator of a finishing material based on a current sensing signal generated by closed-loop feedback system, It is providing a new electrostatic coating system and a method of preventing an electrostatic discharge between a charge applicator of a finishing material, and a target object.
[0011]Another purpose of this invention adjusts dynamically voltage supplied to a charge applicator of a finishing material based on a current sensing signal generated by closed-loop feedback system, Are an electrostatic discharge between a charge applicator of a finishing material, and a target object a new electrostatic coating system and a method of preventing, and the above-mentioned current sensing signal, In order to give an improvement of sensitivity to the comparatively wide range state of expressing urgent discharge, it is providing a new electrostatic coating system and a method one or more of the current in a direct current, a current change rate, and a band pass frequency range by which the filter was carried out being expressed.
[0012]The purpose of this invention is to provide a new electrostatic coating system and a method of raising efficiency of high voltage power which supplies high tension to a charge applicator of a finishing material of an electrostatic coating system. Another purpose of this invention by giving delay between the 1st [which carries out the sink of the variable voltage driving signal supplied to a center tap of a high-tension transformer by turns (sink)], and 2nd complementary driving signals, It is providing a new electrostatic coating system and a method of raising efficiency of high voltage power which supplies high tension to a charge applicator of a finishing material of an electrostatic coating system.
[0013]Another purpose of this invention by changing drive frequency of the 1st and 2nd complementary drivers which carries out the sink of the variable voltage driving signal supplied to a center tap of a high-tension transformer by turns, It is a new electrostatic coating system and a method of raising efficiency of high voltage power which supplies high tension to a charge applicator of a finishing material of an

electrostatic coating system, and is providing a new electrostatic coating system and a method the above-mentioned variable voltage driving signal being made into the minimum to voltage as which an output of a high-tension transformer was chosen.
[0014]Another purpose of this invention by adjusting drive frequency of the 1st and 2nd complementary drivers which carries out the sink of the variable voltage driving signal supplied to a center tap of a high-tension transformer by turns to resonance frequency of a high-tension transformer by a certain phase shift, It is a new electrostatic coating system and a method of raising efficiency of high voltage power which supplies high tension to a charge applicator of a finishing material of an electrostatic coating system, and is providing a new electrostatic coating system and a method voltage of an output of a high-tension transformer being made into the maximum.
[0015]
[Embodiment of the Invention]These and other purposes, the feature, and effect of this invention will be thoroughly understood from detailed explanation of the following which referred to the accompanying drawing in which the same portion and stage were shown with the same reference number. Drawing 1 is a block diagram of the electrostatic coating system 10 generally provided with the charge applicator 100 of a finishing material for turning to the target object T the charge of a finishing material by which electrification was carried out, and giving it. The charge applicator 100 of a finishing material is maintained by comparatively high positive or electronegative potential to the target object T which is usually earth potentials or near the. The operating voltage between the charge applicator 100 of a finishing material and the target object T has a DC voltage ingredient with the size of about 20 kilovolts (kV) thru/or about 100 kV. The actuating current between the charge applicator 100 of a finishing material and the target object T has a DC component with the size of about 20 microampere (muA) thru/or about 1000microA. However, the range of such operating voltage and current, If it is a person skilled in the art, will be only mere illustration, will divide and The conductivity of the charge of a finishing material, Probably, based on the factor of a large number containing the size and shape of the form of the charge applicator of a finishing material, the number of the charge applicators of a finishing material in a system, the distance between the charge applicator of a finishing material, and a target object, and a target object, it will be clear that may be larger than it or it may be small. According to one feature of this invention, such operating voltage and a current parameter, In order to control the voltage impressed to the charge applicator of a finishing material to state below and to control the current between the charge applicator 100 of a finishing material, and the target object T, it changes dynamically within the limits of these, and out of these ranges.
[0016]The charge applicator 100 of a finishing material is the charge grant cancer of a finishing material which generally gives the fluid or powder coating material by which electrification was carried out, charge grant rotary pulverizer of a finishing material, or a charge grant spray pump of a finishing material. In one illustration composition, the charge applicator 100 of a finishing material, As reference. United States patent 5th, 433 which are entitled "non incendive rotary-atomizer (Nonincendive Rotary Atomizer)" as of [of Mr. Howe transferred to the grantee of this invention taken up here] July 18, 1995, As indicated by No. 387, in order to decrease stored energy, it is the rotary pulverizer which has comparatively low capacitance. More generally, the charge applicator 100 of a finishing material expresses two or more charge applicators of a finishing material arranged by parallel electric circuit composition to the common high voltage power of an electrostatic coating system, in order to give the charge of a finishing material towards one or more target objects. The term of the target object used here points out the object (one or more) which forms the discharge path from the charge applicator 100 of a finishing material irrespective of whether it is the target object in which the charge of a finishing material to which the object was given was meant. Therefore, for example, a target object exists near the charge applicator 100 of a finishing material, and also contains the operator and other objects which have produced discharge.
[0017]The system 10 shown in drawing 1 is provided with the high-tension module 200 which has the input 210 and the output 220 connected to the charge applicator 100 of a finishing material. The high-tension module 200 is provided with the high-tension transformer 230 with primary winding and a high-

tension secondary winding in drawing 2, and the secondary winding, It is connected to a high-voltage regulator and the multiplier circuit 240, this changes the high-tension AC signal of the secondary winding of a transformer into a high-tension DC output, and this output is supplied to the charge applicator 100 of a finishing material. This illustration high-tension configuration of module is indicated in detail by U.S. Pat. No. 4,745,520 entitled "the power supply (Power Supply)" as of [of Mr. Fuzee transferred to the grantee of this invention taken up as reference here] May 17, 1988. In the use connected to the high-tension module 200, the single charge applicator 100 of a finishing material. As indicated by the patent of Mr. Fuzee taken up as reference, the high-tension module 200 can be united with the charge applicator 100 of a finishing material, stored energy can be decreased, and it can dissipate comparatively promptly. In the use connected to the high-tension module 200 with parallel composition, many charge applicators of a finishing material. A corresponding high-tension cable connects the high-tension module 200 to the charge applicator of a finishing material of a large number with the individual high-tension module 200, and in this case, since the distance between the high voltage power 200 and the charge applicator 100 of a finishing material decreases stored energy, the minimum is generally used.

[0018]Drawing 1 shows the control module 300 connected to the high-tension module 200, and this control module 300 gives a variable voltage driving signal to the input 210 of a high-tension module, and generates high tension in the output 220 of the high-tension module connected to the charge applicator 100 of a finishing material. The control module 300 shown in drawing 2 is provided with the pulse width modulator 310 and the switching regulator 320. The pulse width modulator 310 answers the control signal from the system controller 400, and generates a variable output signal. In one embodiment, the pulse width modulators 310 are programmable frequency / pulse width generator which generates the output signal of the variable frequency which changes between about 40 kHz thru/or about 60 kHz, and a duty cycle. It is connected to the pulse width modulator 310, and the switching regulator 320 answers the variable output signal, and generates a variable voltage driving signal. The switching regulator 320 supplies a variable voltage driving signal to the center tap 232 of high-tension primary winding, and generates variable high tension in the output of a high-tension transformer. The 1st phase driver 330 is connected to the 1st input 234 of the primary winding of a transformer, and the 2nd phase driver 340 is connected to the 2nd input 236 of the primary input winding of a transformer. The 1st phase driver 330 answers the 1st driving signal from the controller 400, and generates the 1st signal, Carrying out [and] the sink of the variable voltage driving signal given to the center tap 232, the 2nd phase driver 340 answers the 2nd driving signal from the controller 400, generates the 2nd signal by turns, and carries out the sink of the variable voltage driving signal given to the center tap 232. According to this feature of this invention, similarly the 1st signal from the 1st phase driver 330 and the 2nd signal from the 2nd phase driver 340 are the frequency, and 180 degrees of phases have shifted.

[0019]Since the voltage sensing signal showing the high tension between the charge applicator 100 of a finishing material and the target object T is generated, drawing 1 and 2 show the voltage sensing module 500 connected to the output 220 of a high-tension module. In one embodiment, this voltage sensing signal is based on the 1st voltage feedback signal generated by the resistance dividing network of the output 220 of a high-tension module. The resistance dividing network of the 1st voltage feedback suitable for this purpose is indicated in detail by U.S. Pat. No. 4,745,520 entitled "the power supply (Power Supply)" as of [of Mr. Fuzee transferred to the grantee of this invention taken up as reference here] May 17, 1988. The voltage sensing module 500 is connected to the system controller 400 in order to give a voltage sensing signal to the system controller 400. The system controller 400 answers a voltage sensing signal, generates and supplies a control signal to the control module 300, and the high tension of the charge applicator 100 of a finishing material, The control signal from the system controller 400 can be answered, and the control module 300 can adjust to the 1st voltage level between stationary operation. Generally, this 1st voltage level is a voltage level of the user definition selected to the specific paint use, is inputted into the system controller 400 in the user interface 30, and is displayed on the visible indicator 40. In one embodiment, a voltage sensing signal is supplied to the comparator

which generates the control signal for controlling the variable voltage of a pulse width modulator, as indicated in detail by U.S. Pat. No. 4,745,520 entitled the "power supply" as of [of above-mentioned Mr. Fuzee] May 17, 1988. In the embodiment of drawing 2, a voltage sensing signal is supplied to the system controller 400 of a micro processor base through the buffer 20, and and the system controller 400, It is answered, the control signal for controlling the variable output signal generated by the pulse width modulator 310 is generated, and the switching regulator 320 is controlled as mentioned above. Therefore, the voltage of the charge applicator 100 of a finishing material answers a voltage sensing signal, and increases or decreases dynamically so that desired voltage may be given to the charge applicator 100 of a finishing material.

[0020]The current perception module 600 shown in drawing 1, Direct-current (I) between the charge applicator 100 of a finishing material, and the target object T, The current change rate between the charge applicator of a finishing material, and a target object (di/dt), And since the current sensing signal showing at least one or more of current BP(i)s in the band pass frequency range between the charge applicator of a finishing material and a target object by which the filter was carried out is generated, it is connected to the output 220 of a high-tension module. In one embodiment, a current sensing signal is based on the 2nd voltage feedback signal generated with the return passage of the output 220 of the high-tension module to a grounding point, and in-series resistance. The 2nd voltage feedback resistance circuit suitable for this purpose is indicated in detail by U.S. Pat. No. 4,745,520 entitled the "power supply" as of [of Mr. Fuzee transferred to the grantee of this invention taken up as reference here] May 17, 1988. According to this feature of this invention, it is generated from the 2nd voltage feedback signal so that a direct current may be proportional to the DC component of the 2nd voltage feedback signal corresponding to a current sensing signal and a current change rate signal and the current signal by which the filter was carried out may be described below.

[0021]The current perception module 600 is connected to the system controller 400 in order to give a current sensing signal to the system controller 400. The system controller 400 answers a current sensing signal, and generates and supplies a control signal to the control module 300, and the high tension of the charge applicator of a finishing material can answer the control signal from the system controller 400, and can adjust it with the control module 300 dynamically. Therefore, the high tension sent to the charge applicator 100 of a finishing material answers both a voltage sensing signal and a current sensing signal, and is controlled. However, the current sensing signal of a priority is higher than a voltage sensing signal because of the purpose of controlling high tension. A current sensing signal is because the early electrostatic discharge which can generally prevent high voltage by decreasing is expressed. In the embodiment of drawing 2, although a current sensing signal is supplied to the system controller 400 of a micro processor base and a control signal for this to control the variable voltage driving signal of the control module 300 is generated, these control signals may be generated by analog circuitry.

[0022]Generally, a current change rate samples a current sensing signal, and is measured by comparing the signal sampled most recently with the already sampled signal. In one embodiment, the 2nd voltage feedback signal corresponding to a current sensing signal, As explained to U.S. Pat. No. 4,187,527 entitled "the electrostatic coating system (Electrostatic Coating System)" as of [of Mr. Bentley transferred to the grantee of this invention taken up as reference here] February 5, 1980 in detail, The inclination detector circuit incorporating a sample hold circuit is supplied. According to the embodiment of drawing 2, the 2nd voltage feedback signal corresponding to a current sensing signal is supplied to the system controller 400 of a micro processor base through the buffer 22. In this composition, the system controller 400 of a micro processor base acquires the measure of a current change rate as compared with the current sensing signal which sampled the current sensing signal continuously and was already sampled in the current sensing signal sampled most recently. According to one embodiment, the system controller 400 samples the DC component of a current sensing signal, and acquires the measure of a current change rate. The comparatively high sampling rate which can be attained with the system controller 400 of a micro processor base can give the measure of a current change rate in an instant comparatively, and, thereby, the system controller 400 can control the high tension of the charge applicator 100 of a finishing material more respondent. By this improved high voltage control, the

system controller 400, The generally improved operating efficiency can be acquired so that the rise of a current change rate may be answered and the high tension of the charge applicator 100 of a finishing material may be decreased, before a current change rate goes up even to the level which needs to carry out the disable of the high tension of the charge applicator of a finishing material, and it may state in detail below as a result.

[0023]The current in a band pass frequency range by which the filter was carried out is generally measured by carrying out the filter of the current sensing signal with a band-pass filter. As indicated in detail in one embodiment by Mr. Fuzee's U.S. Pat. No. 4,745,520 taken up as reference, The 2nd feedback voltage signal corresponding to a current sensing signal is supplied to the band-pass filter circuit of an analog, and the current in a band pass frequency range by which the filter was carried out is generated. In the embodiment of drawing 2, the 2nd voltage feedback signal corresponding to a current sensing signal, It is sent to the programmable band-pass filter 50 connected to the system controller 400 of a micro processor base by the buffer 24, and this band-pass filter 50 can be programmed with the system controller 400. In one use, the range of a band-pass filter makes about 200 Hz center frequency, and are about 20 Hz thru/or about 2000 Hz. More generally, even if a frequency range is wider, it changes narrowly based on a use with specific center frequency. In one composition, the frequency range which differs in a large number, and the center frequency corresponding to it are memorized by the memory, and are chosen and used in a different charge use of a finishing material. According to this feature of this invention, the output signal of the filter 50 corresponds to the current in a band pass frequency range by which the filter was carried out, and the possibility of the corona discharge in the charge applicator 100 of a finishing material is shown. The system controller 400 controls the high tension which answers the measured level of the current in a band pass frequency range by which the filter was carried out, and is supplied to the charge applicator 100 of a finishing material to state in detail below.

[0024]The high tension supplied to the charge applicator 100 of a finishing material can answer the current sensing signal showing at least one or more of the increase in a direct current, the increase in a current change rate, and the increases in current in a band pass frequency range by which the filter was carried out, and can decrease dynamically. The high tension supplied to the charge applicator 100 of a finishing material can answer the current sensing signal showing at least one or more of reduction in a direct current, reduction of a current change rate, and the reduction of current in a band pass frequency range by which the filter was carried out, and it can be dynamically increased with the control module 300.

[0025]Drawing 3 is a graph which shows the illustration load curve relation between the high tension supplied to the charge applicator 100 of a finishing material, and the charge applicator 100 of a finishing material and a direct current between the target objects T. According to one feature of this invention, the high tension supplied to the charge applicator 100 of a finishing material, The current change rate which increases from a direct current and the 1st current change rate level which go up from 1st direct-current level I_1, And the current sensing signal showing at least one or more of the current in the band pass frequency range which increases from the 1st band pass current level by which the filter was carried out is answered, and it decreases dynamically below to 1st voltage-level V_1. A direct current in which the high tension of the charge applicator of a finishing material decreases toward the 1st direct-current level, The current change rate which decreases toward the 1st current change rate level, and the current sensing signal showing at least one of the current in the band pass frequency range which decrease in number toward the 1st band pass current level by which the filter was carried out are answered, and it is dynamically increased toward 1st voltage-level V_1.

[0026]According to another feature of this invention shown in drawing 3, the high tension supplied to the charge applicator of a finishing material, A disable is answered and carried out to the current sensing signal showing at least one or more of the current in the band pass frequency range exceeding a direct current exceeding direct-current marginal I_{max}, the current change rate exceeding a rate-of-change limit,

and a band-pass filter current limit by which the filter was carried out. When it decreases to the minimum with voltage, the disable of the high tension supplied to the charge applicator of a finishing material may be carried out.
[0027]According to another feature of this invention, when the current sensing signal ingredient which produced the state of impairment disappears to within a time [appointed], the system controller 400 is automatically tried so that the voltage which is supplied to the charge applicator 100 of a finishing material and by which the disable was carried out may be enabled. In one operational mode, the high tension by which the disable was carried out is enabled, for example, when the level of the current in the band pass frequency range showing corona discharge by which the filter was carried out disappears to within a time [appointed]. According to this feature of this invention, before having to reset manually the high tension by which the disable was carried out, the system controller 400 is tried so that a system may be reset repeatedly.
[0028]While giving electric power first to the system 10, and while resetting the system 10 automatically, the variable voltage driving signal supplied to the center tap 232 of a transformer, It inclines in the rise direction toward the 1st voltage level by the predetermined rate of increase under control of the system controller 400, namely, is increased. However, the voltage rate of increase may answer the current sensing signal showing discharge, and may decrease, and a disable may be carried out eventually. The voltage rate of increase is not generally the same at an early upgrade state and an automatic system reset state, and the above quick increase in voltage needed while giving electric power first to a system is needed in an automatic system reset state.
[0029]Although the graph of drawing 3 shows the voltage and the relation of a direct current which include a linear active region substantially, the relation of a voltage-direct current is generally un-linear. although the relation same also between voltage and a current change rate and between the current components to which the filter of voltage and the current sensing signal was carried out exists, the voltage-current relation of these each is peculiar and generally un-linear. Although the current change rate and the parameter of current by which the filter was carried out are peculiar, there is a tendency not to change for every use, so that a direct-current parameter changes for every use. For example, divide the direct-current level needed and The conductivity of the charge of a finishing material, It is dependent on the factor of a large number relevant to the composition and the specific use of the electrostatic coating system containing the size and shape of the form of the charge applicator of a finishing material, the distance between the charge applicator of a finishing material, and a target object, and a target object. Therefore, a direct-current level is a current level which a user defines, it is chosen to a specific paint use, and is inputted into the user interface 30, and is displayed by the visible indicator 40. Generally, it is determined in an experiment and voltage and various relations of current are determined by referring to the engineering specification accepted.
[0030]Generally in the system controller of a micro processor base, the voltage-current relation to the current parameter of a current sensing signal and a voltage sensing signal is controlled by the programmed algorithm. According to this feature of this invention, an algorithm is easily reformed or cast to specific electrostatic coating system composition or use. Many programs with a different voltage-current algorithm can be memorized in the memory relevant to a microprocessor, a desired voltage-current algorithm can be chosen to a specific system configuration and use, and universal high voltage power can also be formed substantially for an electrostatic coating system. The system controller 400 which uses a microprocessor as a base can supervise memory of the data relevant to system performance and the performance, especially the state of impairment of the nonvolatile memory 60, can analyze this later, and can make it the base of voltage control algorithm amendment. The computer 70 connected to the system controller by the serial input / output port 72 can be used for downloading an algorithm to the system controller 400, or uploading data from the memory of a system controller.
[0031]Controlling dynamically the high tension which answers the current sensing signal showing the above-mentioned current parameter, and is supplied to the charge applicator 100 of a finishing material, Since the comparatively wide range state which shows the discharge in which the current parameter drew near will be expressed and sensitivity will be raised, when preventing discharge of an electrostatic

coating system, remarkable progress and improvement are brought about.
[0032]According to another feature of this invention, the operation efficiency of the high-tension module 200 is raised, and discharge between the charge applicator 100 of a finishing material and a target object is prevented. Since a phase sensing signal is generated, drawing 1 shows the phase perception module 700 connected to the output 220 of a high-tension module. This phase perception module 700 is connected also to the system controller 400 in order to give a phase sensing signal to the system controller 400. According to this feature of this invention, the system controller 400 adjusts substantially the drive frequency of the 1st and 2nd signals from the 1st and 2nd phase drivers 330 and 340 in the resonance frequency of the high-tension transformer 230 by a 90-degree phase shift, and makes the voltage signal of the output of a transformer the maximum. The circuit which controls the circuit which generates the phase sensing signal of the output of a transformer, a phase, and frequency, As reference. United States patent 5th, 159 which are entitled "the high-voltage-power control system (High Voltage Power Supply Control System)" as of [of Mr. Fuzee transferred to the grantee of this invention taken up here] October 27, 1992, It is indicated in detail by No. 544. The 1st and 2nd drive frequencies and phases of a driving signal of the phase drivers 330 and 340 are controlled dynamically to consistent with the resonance frequency of the high-tension transformer 230 with the tendency to change when the target object T approaches the charge applicator 100 of a finishing material or separates. [1st and 2nd] If the transformer 230 is operated with the resonance frequency, a possibility of the increase which the voltage which the maximum voltage occurs in the output of a transformer, therefore is supplied to the charge applicator 100 of a finishing material does not expect arising, and causing discharge will be reduced. In the embodiment of drawing 2, it is supplied to the system controller 400 of a micro processor base by the phase feedback signal through the buffer 24, and and the system controller 400, The frequency of the drive frequency of the 1st and 2nd signals from the 1st and 2nd phase drivers 330 and 340 is controlled to consistent with the resonance frequency of the high-tension transformer 230. In one embodiment, the high-tension transformer 230 is a universal winding type transformer, and drive frequency may change between about 45 kHz thru/or about 110 kHz, and to a different use and system configuration, this frequency range may be still wider, or may be narrow.
[0033]According to another feature of this invention, the operation efficiency of the high-tension transformer 230 is further optimized by generating the high tension which decreases the variable voltage driving signal from the control module 300 supplied to the transformer 230, and is sent to the charge applicator 100 of a finishing material. The heat with which this is generated by the high-tension module also decreases, and this is an especially important matter in a hand-held coating gun and the small charge grant device of a finishing material. The stress of a voltage commutation machine and a multiplier will also decrease decreasing the heat of the high-tension module 200, and this will prolong a life of operation. According to this feature of this invention, since a voltage drive sensing signal is generated, the voltage drive perception module 800 is connected to the control module 300. This voltage drive sensing signal is generated by the resistance separator in the variable voltage driving signal generated by the control module 300. The voltage drive perception module 800 is connected also to the system controller 400 in order to give a voltage drive sensing signal to the system controller 400, It is made to change and the system controller 400 determines a sweep, i.e., the drive frequency from which the variable voltage driving signal from the control module 300 serves as the minimum, for the drive frequency of the 1st and 2nd signals from the 1st and 2nd phase drivers 330 and 340. Therefore, drive frequency changes to the frequency from which the variable voltage sent to the high-tension transformer 230 serves as the minimum to the high tension of the request sent to the charge applicator 100 of a finishing material. Although this feature that raises the efficiency of the transformer 230 can also be used alone and it can also be used combining the above-mentioned frequency consistency and the phase shift feature, Drive frequency is changed within limits restricted to the resonance frequency of the transformer 230 in efforts to make into the minimum variable voltage supplied to the transformer 230, and it is accompanied by restrictions of reaching a compromise in consistency of drive frequency and resonance frequency.
[0034]According to another feature of this invention, the operation efficiency of the high-tension

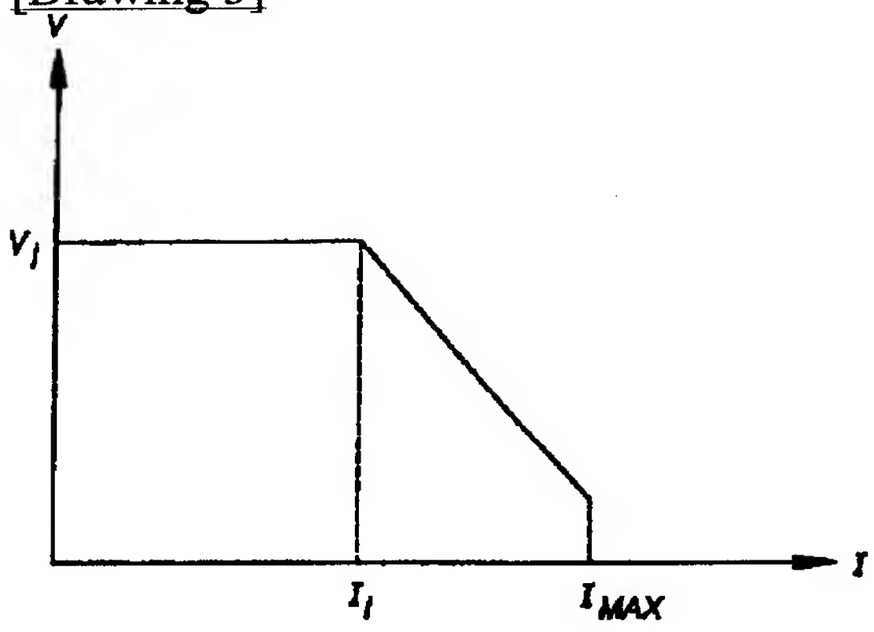
transformer 230 is further optimized by giving delay between the 1st, the 1st of the 2nd phase driver 330 and 340, and the 2nd signal, and allowing collapse of the electric field induced by the transformer with a variable voltage driving signal in front of polarity reversals. This decreases the variable voltage driving signal supplied to the center tap 232 of a transformer, and it decreases the heat generated by the transformer. Drawing 4 shows the delay between the complementary 1st [which drives the 1st and 2nd phase drivers 330 and 340], and 2nd phase driving signals, i.e., a dead space, in order to carry out the sink of the variable voltage driving signal supplied to the center tap 232 of a transformer by turns. According to one feature of this invention, the delay between phase driving signals is fixed delay time. According to another embodiment, in order to determine the time delay which answers the voltage drive sensing signal from the switching regulator 320 to desired output voltage and by which a variable voltage driving signal is made the minimum, a time delay is changed over the small range. This method of raising the efficiency of the high-tension transformer 230 may be used or more combining one of the improvement-in-efficiency features of other of this invention which it could be alone used or was described above.

[0035]the pneuma of the specific embodiment which can carry out and use what is considered the best mode of this invention, and now from the above explanation if it is a person skilled in the art and which was described here although it would come out, and change various by within the limits -- combining and reaching -- etc. -- **** will be understood easily. So, this invention shall not be limited by the above-mentioned specific embodiment, and shall be limited by only the claim.

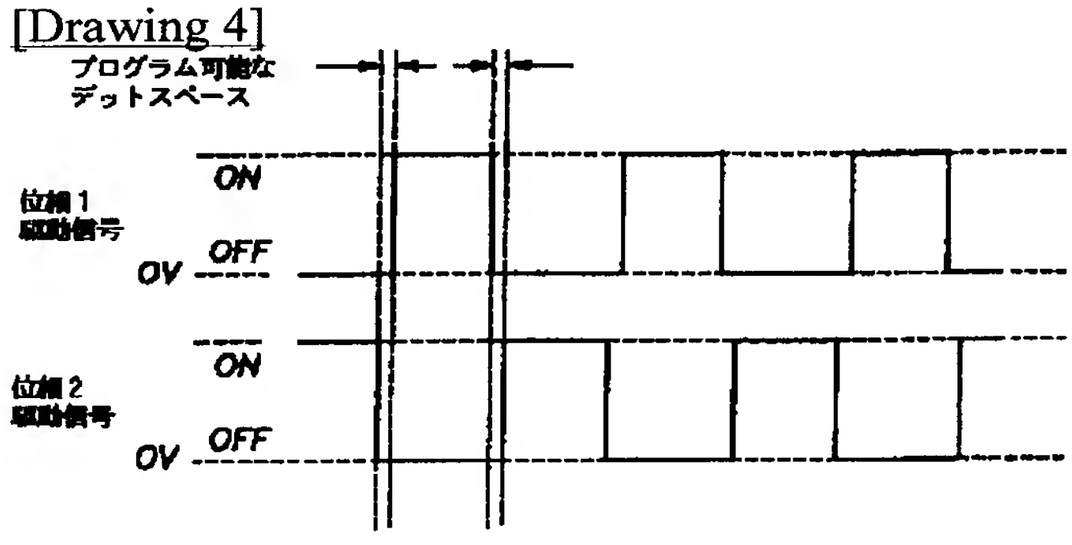
[Translation done.]

DRAWINGS

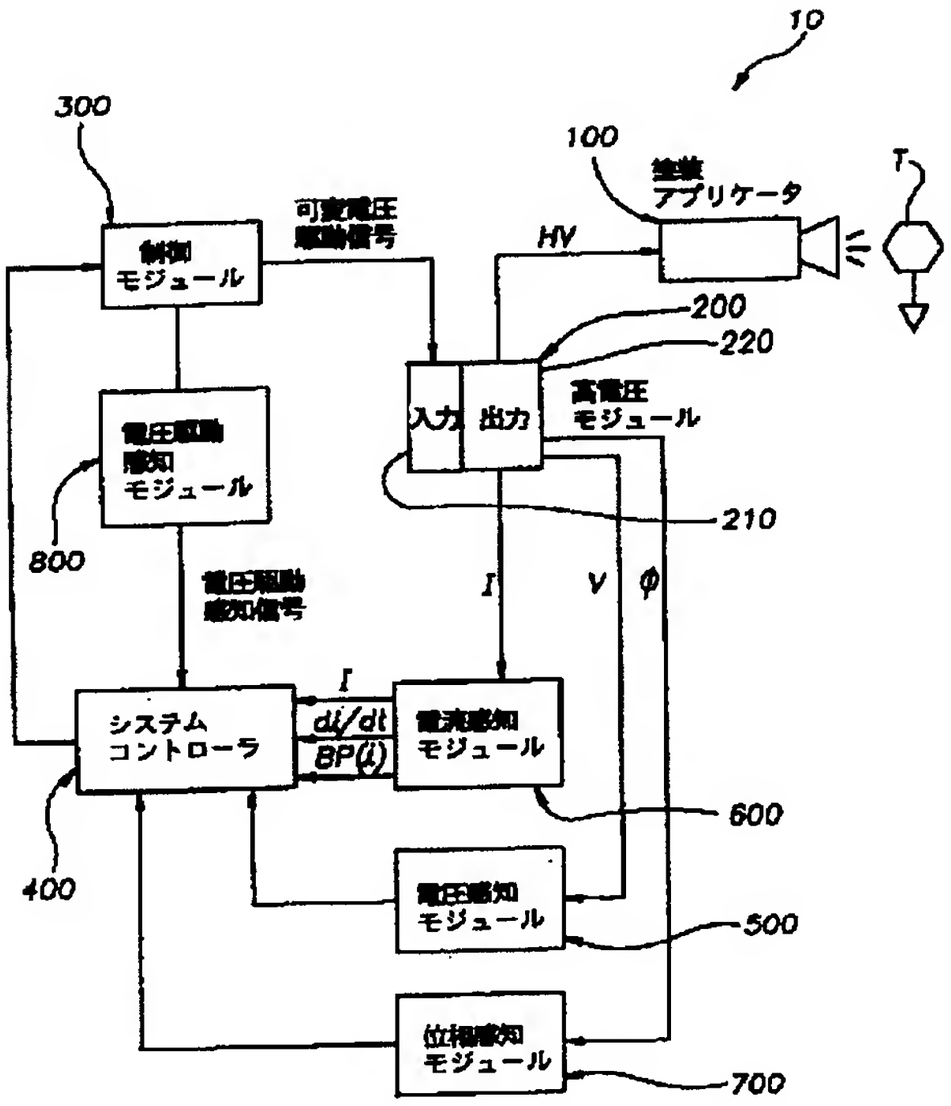
[Drawing 3]



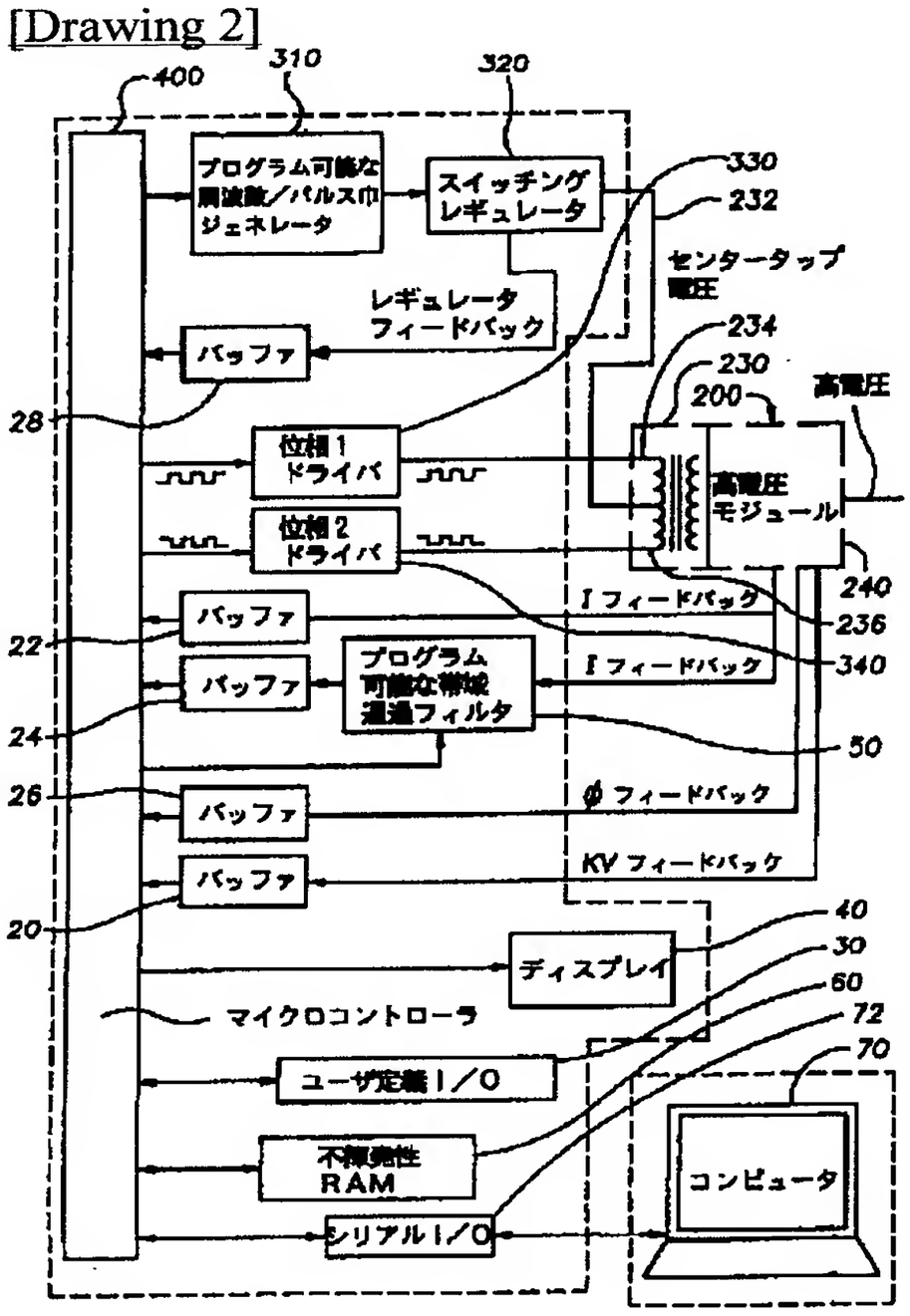
[Drawing 4]



[Drawing 1]



[Drawing 2]



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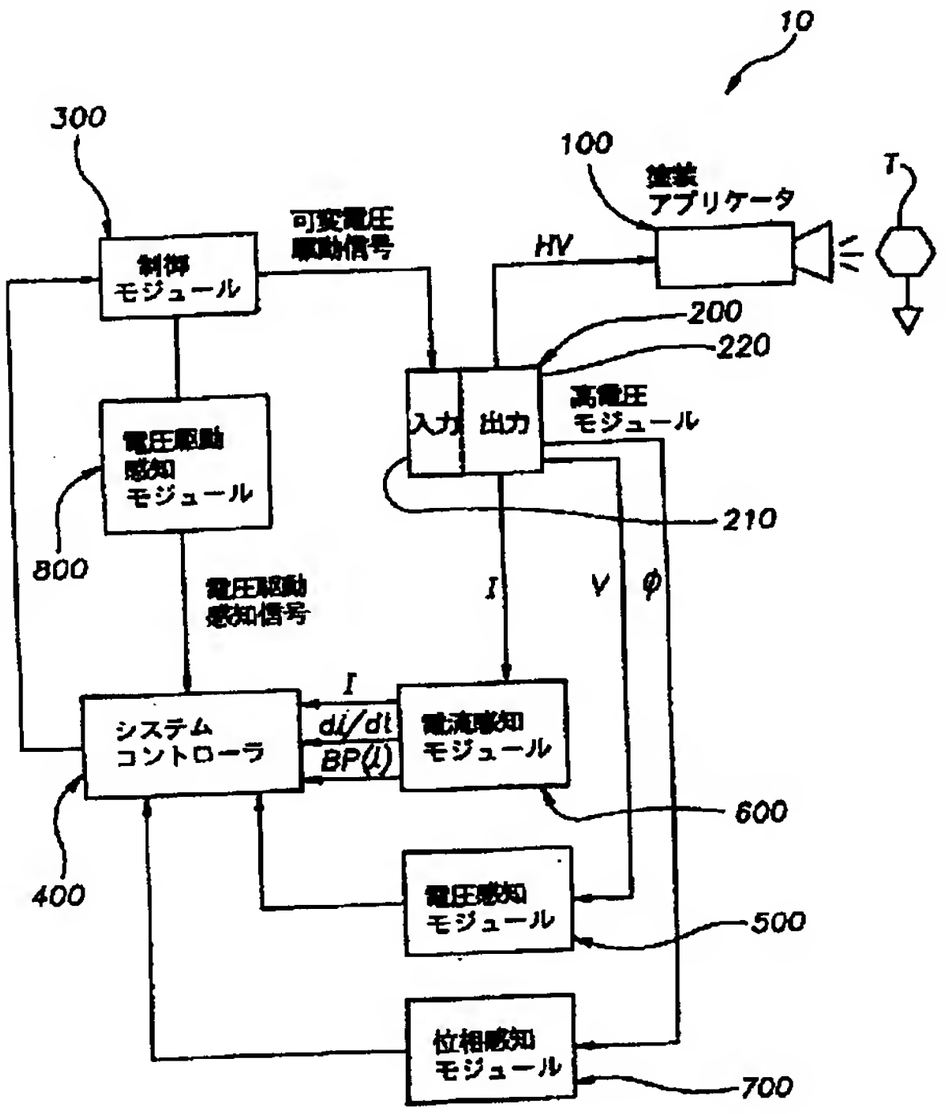
(54)【発明の名称】　静電塗装システム及び方法

(57)【要約】

【課題】　塗装材料アプリケータとターゲット物体との間の静電気放電を防止するために閉ループフィードバックシステムに発生される電圧及び電流感知信号に基づいて塗装材料アプリケータに供給される電圧を制御する静電塗装システム及び方法を提供する。

【解決手段】　電流感知信号は、直流電流、電流変化率及び帯域通過周波数範囲のフィルタされた電流の１つ以上を表し、切迫した放電を示す比較的広範囲な状態に対して改善された感度を与える。塗装材料アプリケータに高電圧を与える高電圧電源の効率は、高電圧変圧器のセンタータップに供給される可変電圧駆動信号を交互にシンクする第１及び第２の相補的な駆動信号間に遅延を与え、これら駆動信号の駆動周波数を変化させて、高電圧変圧器の出力の選択された電圧に対して可変電圧駆動信号を最小にし、そして上記相補的な駆動信号の駆動周波数をある位相ずれで高電圧変圧器の共振周波数に整合させて、高電圧変圧器の出力の電圧を最大にすることにより、高められる。



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【特許請求の範囲】

【請求項１】　ターゲット物体に塗装材料を付着するための静電塗装システムにおいて、

荷電された塗装材料をターゲット物体に向けて付与するための塗装材料アプリケータと、

入力及び出力を有し、出力が上記塗装材料アプリケータに接続された高電圧モジュールと、

上記高電圧モジュールの入力に接続された制御モジュールであって、上記塗装材料アプリケータに送られる高電圧を発生するために可変電圧駆動信号を上記高電圧モジュールの入力に与える制御モジュールと、

上記高電圧モジュールの出力に接続された電流感知モジュールであって、上記塗装材料アプリケータとターゲット物体との間の電流の変化率、及び上記塗装材料アプリケータとターゲット物体との間の帯域通過周波数範囲のフィルタされた電流の少なくとも１つを表す電流感知信号を発生するための電流感知モジュールと、

上記電流感知モジュールにより発生された電流感知信号を受け取るために上記電流感知モジュールに接続されたシステムコントローラであって、電流感知信号に応答して制御モジュールへ制御信号を与えるために制御モジュールに接続されたシステムコントローラとを備え、

上記塗装材料アプリケータに送られる高電圧は、上記電流変化率の増加及び上記帯域通過周波数範囲のフィルタされた電流の増加の少なくとも１つを表す電流感知信号に応答して制御モジュールにより減少することができ、

そして上記塗装材料アプリケータに送られる高電圧は、上記電流変化率の減少及び上記帯域通過周波数範囲のフィルタされた電流の減少の少なくとも１つを表す電流感知信号に応答して制御モジュールにより増加することができる、ことを特徴とする静電塗装システム。

【請求項２】　上記制御モジュールは、

上記システムコントローラに接続され、上記システムコントローラからの制御信号に応答して可変出力信号を発生するパルス巾変調器と、

上記パルス巾変調器に接続され、上記パルス巾変調器の可変出力信号に応答して可変電圧駆動信号を発生するためのスイッチングレギュレータであって、上記高電圧モジュールの入力に接続されて、その高電圧モジュールの入力に可変電圧駆動信号を与えるためのスイッチングレギュレータとを備え、

上記高電圧モジュールは、上記スイッチングレギュレータからの可変電圧駆動信号に応答して、上記塗装材料アプリケータへ送られる可変高電圧を発生する請求項１に記載のシステム。

【請求項３】　上記高電圧モジュールは、センタータップ付きの一次入力巻線及び二次出力巻線を有する変圧器を備え、上記センタータップは上記制御モジュールに接続され、上記制御モジュールは、上記一次入力巻線のセンタータップに可変電圧駆動信号を与え、

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上記制御モジュールは、更に、上記変圧器の一次入力巻線の第１入力に接続された第１位相ドライバであって、第１駆動信号に応答して、上記センタータップに送られる可変電圧駆動信号をシンクするための第１位相ドライバと、上記変圧器の一次入力巻線の第２入力に接続された第２位相ドライバであって、第２駆動信号に応答して、上記センタータップに送られる可変電圧駆動信号をシンクするための第２位相ドライバとを更に備え、

上記システムコントローラは、上記第１位相ドライバ及び第２位相ドライバに接続され、そして上記システムコントローラは、第１位相ドライバに第１駆動信号を与えそしてそれと交互に第２位相ドライバに第２駆動信号を与え、これらの第１駆動信号及び第２駆動信号は、共通の駆動周波数であって、１８０°位相がずれている請求項１に記載のシステム。

【請求項４】　位相感知信号を発生するために上記高電圧モジュールの出力に接続された位相感知モジュールを更に備え、この位相感知モジュールは、上記システムコントローラに位相感知信号を与えるためにそのシステムコントローラに接続され、上記システムコントローラは、駆動周波数をある位相ずれで上記高電圧モジュールの共振周波数に実質的に整合させて、位相感知信号に応答して高電圧モジュールの効率を高める請求項３に記載のシステム。

【請求項５】　第１駆動信号と第２駆動信号のとの間に遅延を含み、この遅延が上記高電圧モジュールの効率を高める請求項３に記載のシステム。

【請求項６】　電圧駆動感知信号を発生するために制御モジュールに接続された電圧駆動感知モジュールを更に備え、この電圧駆動感知モジュールは、上記システムコントローラへ電圧駆動感知信号を与えるためにそのシステムコントローラに接続され、そして上記システムコントローラは、電圧駆動感知信号に応答して制御モジュールからの可変電圧駆動信号が減少されるところの駆動周波数を決定するために駆動周波数を変化させる請求項３に記載のシステム。

【請求項７】　電圧感知信号を発生するために上記高電圧モジュールの出力に接続された電圧感知モジュールを更に備え、この電圧感知モジュールは、上記システムコントローラに電圧感知信号を与えるためにそのシステムコントローラに接続され、そして上記システムコントローラは、電圧感知信号に応答して上記制御モジュールへ制御信号を与え、上記塗装材料アプリケータに送られる高電圧は、上記システムコントローラに与えられた電圧感知信号に応答して上記制御モジュールにより第１電圧レベルに調整できる請求項１に記載のシステム。

【請求項８】　上記塗装材料アプリケータは、荷電された塗装材料をターゲット物体に向けて付与する複数の塗装材料アプリケータである請求項１に記載のシステム。

【請求項９】　上記高電圧モジュールは、電圧マルチプ

ライヤに接続された普遍的な巻線型変成器を備え、この普遍的な巻線型変成器の一次巻線は、上記制御モジュールに接続され、そして上記電圧マルチプライヤの出力は、塗装材料アプリケータに接続される請求項１に記載のシステム。

【請求項１０】　ターゲット物体に塗装材料を付着するための静電塗装システムにおいて、

荷電された塗装材料をターゲット物体に向けて付与するための塗装材料アプリケータと、

センタータップ付きの一次入力巻線と、上記塗装材料アプリケータに接続された高電圧モジュール出力とを有する高電圧モジュールと、

上記高電圧モジュールに接続され、上記塗装材料アプリケータに供給される高電圧を発生するために上記高電圧モジュールのセンタータップに可変電圧駆動信号を与える制御モジュールと、

上記高電圧モジュールの一次入力巻線の第１入力に接続され、第１駆動信号に応答して、上記センタータップに送られる可変電圧駆動信号をシンクするための第１の位相ドライバと、

上記高電圧モジュールの一次入力巻線の第２入力に接続され、第２駆動信号に応答して、上記センタータップに送られる可変電圧駆動信号をシンクするための第２の位相ドライバと、

上記第１位相ドライバ及び第２位相ドライバに接続されたシステムコントローラであって、第１駆動信号を第１位相ドライバに与えると共に、第２駆動信号を第２位相ドライバに交互に与え、第１駆動信号及び第２駆動信号は、共通の駆動周波数であって且つ１８０°位相ずれしているようなシステムコントローラと、

電圧駆動感知信号を発生するために上記制御モジュールに接続された電圧駆動感知モジュールであって、システムコントローラに電圧駆動感知信号を与えるためにシステムコントローラに接続された電圧駆動感知モジュールとを備え、

上記制御モジュールからの可変電圧駆動信号は、第１駆動信号と第２駆動信号との間に１つの遅延を与えそして駆動周波数を変更することにより電圧駆動感知信号に応答して減少されることを特徴とする静電塗装システム。

【請求項１１】　上記塗装材料アプリケータとターゲット物体との間の直流電流、上記塗装材料アプリケータとターゲット物体との間の電流の変化率、及び上記塗装材料アプリケータとターゲット物体との間の帯域通過周波数範囲のフィルタされた電流の少なくとも１つを表す電流感知信号を発生するために上記高電圧モジュールの出力に接続された電流感知モジュールを更に備え、

上記システムコントローラは、上記電流感知モジュールにより発生された電流感知信号を受け取るために電流感知モジュールに接続され、そして上記システムコントローラは、電流感知信号に応答して上記制御モジュールへ

制御信号を与えるために上記制御モジュールに接続され、

上記塗装材料アプリケータに供給される高電圧は、上記直流電流の増加、上記電流変化率の増加及び上記帯域通過周波数範囲のフィルタされた電流の増加の少なくとも１つを表す電流感知信号に応答して制御モジュールにより減少することができ、そして上記塗装材料アプリケータに供給される高電圧は、上記直流電流の減少、上記電流変化率の減少及び上記帯域通過周波数範囲のフィルタされた電流の減少の少なくとも１つを表す電流感知信号に応答して制御モジュールにより増加することができる請求項１０に記載のシステム。

【請求項１２】　位相感知信号を発生するために上記高電圧モジュールの出力に接続された位相感知モジュールを更に備え、この位相感知モジュールは、上記システムコントローラに位相感知信号を与えるためにそのシステムコントローラに接続され、上記システムコントローラは、駆動周波数をある位相ずれで上記高電圧モジュールの共振周波数に実質的に整合させて、位相感知信号に応答して高電圧モジュールの効率を高める請求項１０に記載のシステム。

【請求項１３】　静電塗装システムによりターゲット物体に塗装材料を付着するための方法において、

塗装材料アプリケータによりターゲット物体に向けて荷電された塗装材料を付与し、

上記塗装材料アプリケータに接続された出力を有する高電圧モジュールにより上記塗装材料アプリケータに高電圧を供給し、

高電圧モジュールの入力に可変電圧駆動信号を与えて、その高電圧モジュールの入力に接続された制御モジュールにより高電圧モジュールの出力に高電圧を発生し、

高電圧モジュールの出力に接続された電流感知モジュールにより、上記塗装材料アプリケータとターゲット物体との間の電流の変化率信号、及び上記塗装材料アプリケータとターゲット物体との間の帯域通過周波数範囲のフィルタされた電流信号の少なくとも１つを表す電流感知信号を発生し、

上記電流感知モジュール及び制御モジュールに接続されたシステムコントローラにより電流感知信号に応答して制御モジュールへ制御信号を与え、

上記塗装材料アプリケータに供給される高電圧を、上記電流変化率の増加及び上記帯域通過周波数範囲のフィルタされた電流の増加の少なくとも１つを表す電流感知信号に応答して上記制御モジュールにより減少し、そして上記塗装材料アプリケータに供給される高電圧を、上記電流変化率の減少及び上記帯域通過周波数範囲のフィルタされた電流の減少の少なくとも１つを表す電流感知信号に応答して上記制御モジュールにより増加する、という段階を備えたことを特徴とする方法。

【請求項１４】　変化率限界を越える電流変化率、及び

帯域通過フィルタ電流限界を越える帯域通過周波数範囲のフィルタされた電流の少なくとも１つを表す電流感知信号に応答して上記制御モジュールにより上記塗装材料アプリケータに供給される高電圧をディスエイブルするという段階を更に備えた請求項１３に記載の方法。

【請求項１５】　直流電流の増加を表す電流感知信号に応答して制御モジュールにより塗装材料アプリケータに供給される高電圧を減少し、そして直流電流の減少を表す電流感知信号に応答して制御モジュールにより塗装材料アプリケータに供給される高電圧を増加するという段階を更に備えた請求項１３に記載の方法。

【請求項１６】　直流電流限界を越える直流電流を表す電流感知信号に応答して制御モジュールにより塗装材料アプリケータに供給される高電圧をディスエイブルするという段階を更に備えた請求項１５に記載の方法。

【請求項１７】　上記塗装材料アプリケータに供給される高電圧を、第１の直流電流レベルより増加する直流電流、第１の電流変化率レベルより増加する電流変化率、及び第１の帯域通過電流レベルより増加する帯域通過周波数範囲のフィルタされた電流の少なくとも１つを表す電流感知信号に応答して、制御モジュールにより第１電圧レベルより低く減少し、そして上記塗装材料アプリケータに供給される高電圧を、第１の直流電流レベルに向かって減少する直流電流、第１の電流変化率レベルに向かって減少する電流変化率、及び第１の帯域通過電流レベルに向かって減少する帯域通過周波数範囲のフィルタされた電流の少なくとも１つを表す電流感知信号に応答して、制御モジュールにより第１電圧レベルに向かって増加する、という段階を更に備えた請求項１３に記載の方法。

【請求項１８】　上記高電圧モジュールは、センタータップ付きの一次入力巻線及び二次出力巻線を有する変圧器を備え、上記センタータップは上記制御モジュールに接続され、上記制御モジュールは、上記変圧器の一次入力巻線の第１入力に接続された第１位相ドライバと、上記変圧器の一次入力巻線の第２入力に接続された第２位相ドライバとを更に備え、上記システムコントローラは、上記第１位相ドライバ及び第２位相ドライバに接続され、上記方法は、更に、

上記変圧器の一次入力巻線のセンタータップに可変電圧駆動信号を供給し、

上記第１位相ドライバに第１駆動信号を与えそしてそれと交互に上記第２位相ドライバに第２駆動信号を与え、これら第１駆動信号及び第２駆動信号は、共通の駆動周波数であって、１８０°位相がずれており、

上記第１位相ドライバからの第１駆動信号に応答して上記センタータップに供給される可変電圧駆動信号をシンクし、そして上記第２位相ドライバからの第２駆動信号に応答して上記センタータップに供給される可変電圧駆動信号を交互にシンクする、という段階を備えた請求項１３に記載の方法。

【請求項１９】　上記高電圧モジュールの出力に接続された位相感知モジュールにより位相感知信号を発生し、上記位相感知信号をシステムコントローラへ供給し、上記位相感知モジュールはシステムコントローラに接続され、そして駆動周波数をある位相ずれで高電圧モジュールの共振周波数に実質的に整合させて、上記位相感知信号に応答して高電圧モジュールの効率を高める、という段階を更に備えた請求項１８に記載の方法。

【請求項２０】　第１駆動信号と第２駆動信号との間に遅延を与え、高電圧モジュールの効率を高める請求項１８に記載の方法。

【請求項２１】　上記制御モジュールに接続された電圧駆動感知モジュールにより電圧駆動感知信号を発生し、上記電圧駆動感知信号をシステムコントローラに供給し、上記電圧駆動感知モジュールは、システムコントローラに接続され、そして上記電圧駆動感知信号に応答して制御モジュールからの可変電圧駆動信号を減少するように駆動周波数を変化させる、という段階を備えた請求項１８に記載の方法。

【請求項２２】　上記高電圧モジュールの出力に接続された電圧感知モジュールにより電圧感知信号を発生し、上記電圧感知信号をシステムコントローラに供給し、上記電圧感知モジュールは、システムコントローラに接続され、そして上記電圧感知信号に応答して制御モジュールに制御信号を与え、上記塗装材料アプリケータの高電圧を第１電圧レベルに調整する、という段階を備えた請求項１８に記載の方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、ターゲット物体に塗装材料を付着する静電塗装システム及び方法に係り、より詳細には、静電塗装システムの塗装材料アプリケータからの放電を防止すると共に、静電塗装システムの塗装材料アプリケータに高電圧を供給する高電圧電源の効率を高めることに係る。

【０００２】

【従来の技術】静電塗装システムは、静止しているか又はコンベアに沿って移動されるターゲット物体に静電気的に荷電された流体又は粉体の塗装材料を付与し、塗装材料をターゲット物体に実質的に均一に付着するのに使用される。これらシステムは、一般に、ターゲット物体に対して高い電位に維持された塗装材料アプリケータを備えている。この塗装材料アプリケータは、常にそうではないが通常は負の電位であり、そしてターゲット物体は、接地電位又はその付近に維持される。ここで使用する塗装材料アプリケータという用語は、粉体及び流体の塗装材料を荷電しそしてその荷電された塗装材料をターゲット物体に向けて付与するためのある種の装置を指す。これらの塗装材料アプリケータは、例えば、参考と

してここに取り上げる本発明の譲受人であるランスバーグコーポレーションに譲渡されたハウ氏等の１９９５年７月１８日付けの「ノンインセンディブロータリーアトマイザー(Nonincendive Rotary Atomizer)」と題する米国特許第５，４３３，３８７号に開示されたように、とりわけ、塗装材料付与ガン、塗装材料付与ベル及び塗装材料付与噴霧器を含む。

【０００３】塗装材料アプリケータとターゲット物体との間の比較的高い電圧は、塗装材料アプリケータと、操作者を含むターゲット物体との間に生じる放電又はスパークの電位により操作者への実質的な感電の危険性を招く。更に、多くの塗装材料は揮発性及び可燃性であるために、放電が生じると着火し、傷害の危険性も招く。静電塗装システムを運転する場合は、オキュペーション・セーフティ・アンド・ヘルス・アクト（ＯＳＨＡ）に基づく作業場安全規定が適用され、責任保険業者は、若干の例外を除いて、静電塗装の運転が、噴霧仕上げ作業に関するナショナル・ファイア・プロテクション・アソシエーション（ＮＦＰＡ）規格に合致して行われることを要求する。従って、政府条例及び工業規格に合致しそして操作者への傷害のおそれを減少するために静電塗装システムの放電を防止することが望まれる。

【０００４】

【発明が解決しようとする課題】静電塗装システムの放電のおそれの減少に向かって既に幾つかの進歩が見られる。例えば、本発明の譲受人であるランスバーグコーポレーションに譲渡されたベントリー氏の１９８０年２月５日付けの「静電塗装システム(Electrostatic Coating System)」と題する米国特許第４，１８７，５２７号においては、抵抗値の低い放電抵抗を有する短絡装置が、スパーク状態が差し迫ったときに塗装材料アプリケータとターゲット物体との間の高電圧をゼロまで迅速に減少する。より詳細には、この放電装置は、塗装材料アプリケータとターゲット物体との間に過剰な電流又は過剰な電流変化率が検出されるのに応答して制御回路によりイネーブルされる。これらの検出される電流パラメータは、一般に、塗装材料アプリケータとターゲット物体との間の距離、ターゲット物体のサイズ及び形状、そしてターゲット物体が塗装材料アプリケータに対して移動する割合に依存している。従って、ベントリー氏は、電気スパークが差し迫ったときに塗装材料アプリケータの電圧を急激にディスエイブルすることによって放電を防止する。しかしながら、ベントリー氏は、変化する電流パラメータに応答して塗装材料アプリケータの電圧を変化させない。むしろ、ベントリー氏の塗装材料アプリケータの高電圧は、電流パラメータの限界を越えたときだけ、変化する電流パラメータの影響を受け、そのとき、電圧は完全にディスエイブルされ、手動でリセットしなければならない。

【０００５】これも本発明の譲受人であるランスバーグコーポレーションに譲渡されたヒュージ氏の１９８８年５月１７日付けの「電源(Power Supply)」と題する米国特許第４，７４５，５２０号は、塗装材料アプリケータに接続された高電圧発生器を有する静電塗装システムを開示している。塗装材料アプリケータの高電圧は、電気的スパークが差し迫ったときに、高電圧出力及び塗装材料アプリケータの高い抵抗値及び高いキャパシタンスを実質的に除去することにより比較的迅速に放電される。高電圧発生器は、高電圧変圧器を備え、そのセンタータップされた一次巻線は、パルス巾変調の駆動信号により駆動され、この駆動信号は、固定周波数発振器の制御のもとで一次巻線の２つの半部分を経て交互にスイッチされる。パルス巾変調の駆動信号は、制御信号に応答して、塗装材料アプリケータの高電圧を電圧フィードバック信号に基づいて調整する。高電圧発生器は、塗装材料アプリケータとターゲット物体との間に検出された過負荷電流に応答して、一次巻線のセンタータップから電圧を除去しそして塗装材料アプリケータの高電圧を一連の抵抗を経て放電することにより、ディスエイブルされる。しかしながら、ヒュージ氏のシステムは、過負荷電流状態に応答して高電圧発生器がディスエイブルされたときには手動でリセットしなければならない。又、高電圧発生器は、コロナ放電を表す信号に応答して瞬間的にディスエイブルされるが、コロナ放電を表す信号の発生が特定の時間周期内に不連続となる場合だけイネーブルされる。それ以外は、ヒュージ氏のシステムは、過負荷電流状態の場合と同様に手動でリセットされねばならない。又、ヒュージ氏も、変化する電流パラメータに応答して塗装材料アプリケータの電圧を変化させない。むしろ、ヒュージ氏の塗装材料アプリケータの高電圧は、ベントリー氏と同様に、電流パラメータの限界を越えたときだけ完全にディスエイブルされる。ヒュージ氏は、指定の時間周期内に電流欠陥が補正された場合に自動的なシステム回復を与え、さもなくば、システムは手動でリセットされねばならない。

【０００６】インジアナ州、インジアナポリスのランズバーグコーポレーションから入手できるＲａｎｓ－Ｐａｋ（登録商標）１０００電源は、高電圧変圧器及び一体的なカスケード変圧器を備え、塗装材料アプリケータに高電圧出力を供給する。塗装材料アプリケータの高電圧は、塗装材料アプリケータとターゲット物体との間の多数の電流パラメータに基づいて制御される。第１に、塗装材料アプリケータの高電圧は、ヒュージ氏の米国特許第４，７４５，５２０号について上記したのと同様に、直流過負荷状態に応答してディスエイブルされる。第２に、高電圧は、直流スレッシュホールドと、直流過負荷状態に対応する直流値との間の直流変化として動的に変化される。高電圧は、ターゲット物体が塗装材料アプリケータに近づくときは増加する直流に応答して急勾配の負荷線に沿って減少され、そして電圧は、ターゲット物

体が塗装材料アプリケータから離れるときには減少する直流に応答して同じ急勾配の負荷線に沿って増加される。しかしながら、この構成によれば、電圧は、急勾配の負荷線により比較的狭い範囲の直流変化にわたって制御される。又、Ｒａｎｓ－Ｐａｋ（登録商標）１０００電源は、電流変化率の変動及びコロナ放電を表す電流パラメータに応答する動的な電圧制御を含んでいない。従って、Ｒａｎｓ－Ｐａｋ（登録商標）１０００電源は、放電を防止するために塗装材料アプリケータの高電圧の不必要なディスエイブル動作を被ることになる。

【０００７】これも本発明の譲受人であるランスバーグコーポレーションに譲渡されたヒュージ氏等の１９９２年１０月２７日付けの「高電圧電源制御システム(High Voltage Power Supply Control System)」と題する米国特許第５，１５９，５４４号は、高電圧変圧器を含む高電圧発生器に接続された塗装材料アプリケータを備えていて、上記高電圧発生器がその共振周波数で動作され、最大出力電圧を与えると共に、放電のおそれを減少するような静電塗装システムを開示している。電圧制御発振器は、高電圧変圧器の一次巻線を駆動するための出力信号を与える。位相比較器は、電圧制御発振器の出力信号位相と、高電圧変圧器の二次巻線の出力信号位相とに基づいて制御信号を発生する。位相比較器の制御信号は、電圧制御発振器により発生される出力信号の周波数を変えるのに使用され、高電圧変圧器の二次巻線の出力信号に対し９０°の位相ずれが生じるようにする。従って、高電圧変圧器は、その最大出力電圧で動作され、放電を生じる予期せぬ電圧サージのおそれを防止する。

【０００８】以上の説明から、とりわけ、公知の静電塗装システム及びその方法を改善する必要性があることが明らかである。

【０００９】

【課題を解決するための手段】それ故、本発明の目的は、公知の問題を克服する新規な静電塗装システム及び方法を提供することである。又、本発明の目的は、塗装材料アプリケータとターゲット物体との間の放電のおそれを減少する新規な静電塗装システム及び方法を提供することである。

【００１０】本発明の別の目的は、閉ループフィードバックシステムに発生された電流感知信号に基づいて塗装材料アプリケータへ供給される電圧を動的に調整し、塗装材料アプリケータとターゲット物体との間の静電気放電を防止する新規な静電塗装システム及び方法を提供することである。

【００１１】本発明の更に別の目的は、閉ループフィードバックシステムに発生された電流感知信号に基づいて塗装材料アプリケータへ供給される電圧を動的に調整し、塗装材料アプリケータとターゲット物体との間の静電気放電を防止する新規な静電塗装システム及び方法であって、上記電流感知信号は、切迫した放電を表す比較

的広範囲な状態に対して感度の改善を与えるために、直流電流、電流変化率及び帯域通過周波数範囲におけるフィルタされた電流の１つ以上を表すような新規な静電塗装システム及び方法を提供することである。

【００１２】又、本発明の目的は、静電塗装システムの塗装材料アプリケータに高電圧を供給する高電圧電源の効率を高める新規な静電塗装システム及び方法を提供することである。本発明の別の目的は、高電圧変圧器のセンタータップへ供給される可変電圧駆動信号を交互にシンクする(sink)第１及び第２の相補的な駆動信号間に遅延を与えることにより、静電塗装システムの塗装材料アプリケータに高電圧を供給する高電圧電源の効率を高める新規な静電塗装システム及び方法を提供することである。

【００１３】本発明の別の目的は、高電圧変圧器のセンタータップへ供給される可変電圧駆動信号を交互にシンクする第１及び第２の相補的なドライバの駆動周波数を変えることにより、静電塗装システムの塗装材料アプリケータに高電圧を供給する高電圧電源の効率を高める新規な静電塗装システム及び方法であって、上記可変電圧駆動信号が高電圧変圧器の出力の選択された電圧に対して最小にされる新規な静電塗装システム及び方法を提供することである。

【００１４】本発明の更に別の目的は、高電圧変圧器のセンタータップへ供給される可変電圧駆動信号を交互にシンクする第１及び第２の相補的なドライバの駆動周波数をある位相ずれで高電圧変圧器の共振周波数に整合することにより、静電塗装システムの塗装材料アプリケータに高電圧を供給する高電圧電源の効率を高める新規な静電塗装システム及び方法であって、高電圧変圧器の出力の電圧が最大にされるような新規な静電塗装システム及び方法を提供することである。

【００１５】

【発明の実施の形態】本発明のこれら及び他の目的、特徴並びに効果は、同様の部分及び段階が同じ参照番号で示された添付図面を参照した以下の詳細な説明から完全に理解されよう。図１は、荷電された塗装材料をターゲット物体Ｔに向けて付与するための塗装材料アプリケータ１００を一般的に備えた静電塗装システム１０のブロック図である。塗装材料アプリケータ１００は、通常接地電位又はその付近にあるターゲット物体Ｔに対して比較的高い正又は負の電位に維持される。塗装材料アプリケータ１００とターゲット物体Ｔとの間の動作電圧は、約２０キロボルト（ｋＶ）ないし約１００ｋＶの大きさをもつＤＣ電圧成分を有する。塗装材料アプリケータ１００とターゲット物体Ｔとの間の動作電流は、約２０マイクロアンペア（μＡ）ないし約１０００μＡの大きさをもつＤＣ成分を有する。しかしながら、これらの動作電圧及び電流の範囲は、単なる例示に過ぎず、当業者であれば、とりわけ、塗装材料の導電率、塗装材料アプリ

ケータの形式、システムにおける塗装材料アプリケータの数、塗装材料アプリケータとターゲット物体との間の距離、そしてターゲット物体のサイズ及び形状を含む多数のファクタに基づいて、それより大きくても小さくてもよいことが明らかであろう。更に、本発明の１つの特徴によれば、これらの動作電圧及び電流パラメータは、以下に述べるように、塗装材料アプリケータに印加される電圧を制御すると共に、塗装材料アプリケータ１００とターゲット物体Ｔとの間の電流を制御するために、これらの範囲内及びこれらの範囲外で動的に変化される。

【００１６】塗装材料アプリケータ１００は、一般に、荷電された液体又は粉体塗装材料を付与する塗装材料付与ガン、又は塗装材料付与ロータリー噴霧器、又は塗装材料付与噴霧器である。１つの例示的構成においては、塗装材料アプリケータ１００は、参考としてここに取り上げる本発明の譲受人に譲渡されたハウ氏等の１９９５年７月１８日付けの「ノンインセンディブロータリーアトマイザー(Nonincendive Rotary Atomizer)」と題する米国特許第５，４３３，３８７号に開示されたように蓄積エネルギーを減少するために比較的低いキャパシタンスを有するロータリー噴霧器である。塗装材料アプリケータ１００は、より一般的には、１つ以上のターゲット物体に向けて塗装材料を付与するために静電塗装システムの共通の高電圧電源に対して並列な電気回路構成に配列された複数の塗装材料アプリケータを表す。又、ここで使用するターゲット物体という用語は、その物体が付与された塗装材料の意図されたターゲット物体であるかどうかに係わりなく塗装材料アプリケータ１００からの放電路を形成する物体（１つ又は複数）を指す。従って、例えば、ターゲット物体は、塗装材料アプリケータ１００の付近に存在して、放電を生じさせることのある操作者及び他の物体も含む。

【００１７】図１に示されたシステム１０は、入力２１０と、塗装材料アプリケータ１００に接続された出力２２０とを有する高電圧モジュール２００を備えている。図２において、高電圧モジュール２００は、一次巻線及び高電圧二次巻線をもつ高電圧変圧器２３０を備え、その二次巻線は、高電圧整流器・マルチプライヤ回路２４０に接続され、これは、変圧器の二次巻線の高電圧ＡＣ信号を高電圧ＤＣ出力に変換し、この出力が塗装材料アプリケータ１００に供給される。この例示的な高電圧モジュール構成は、参考としてここに取り上げる本発明の譲受人に譲渡されたヒュージ氏の１９８８年５月１７日付けの「電源(Power Supply)」と題する米国特許第４，７４５，５２０号に詳細に開示されている。単一の塗装材料アプリケータ１００が高電圧モジュール２００に接続される用途では、参考として取り上げるヒュージ氏の特許に開示されたように、高電圧モジュール２００を塗装材料アプリケータ１００と一体化し、蓄積エネルギーを減少して、比較的迅速に消散することができる。多数の塗装材料アプリケータが並列な構成で高電圧モジュール２００に接続される用途では、対応する高電圧ケーブルが高電圧モジュール２００を高電圧モジュール２００とは個別の多数の塗装材料アプリケータに接続し、この場合には、高電圧電源２００と塗装材料アプリケータ１００との間の距離が蓄積エネルギーを減少するために一般的に最小にされる。

【００１８】図１は、高電圧モジュール２００に接続された制御モジュール３００を示しており、この制御モジュール３００は、高電圧モジュールの入力２１０に可変電圧駆動信号を与え、塗装材料アプリケータ１００に接続された高電圧モジュールの出力２２０に高電圧を発生する。図２に示された制御モジュール３００は、パルス巾変調器３１０及びスイッチングレギュレータ３２０を備えている。パルス巾変調器３１０は、システムコントローラ４００からの制御信号に応答して、可変出力信号を発生する。１つの実施形態において、パルス巾変調器３１０は、約４０ｋＨｚないし約６０ｋＨｚの間で変化する可変周波数及びデューティサイクルの出力信号を発生するプログラム可能な周波数／パルス巾ジェネレータである。スイッチングレギュレータ３２０は、パルス巾変調器３１０に接続され、その可変出力信号に応答して可変電圧駆動信号を発生する。スイッチングレギュレータ３２０は、高電圧一次巻線のセンタータップ２３２に可変電圧駆動信号を供給して、高電圧変圧器の出力に可変高電圧を発生する。第１の位相ドライバ３３０は変圧器の一次巻線の第１入力２３４に接続され、そして第２位相ドライバ３４０は変圧器の一次入力巻線の第２入力２３６に接続される。第１の位相ドライバ３３０は、コントローラ４００からの第１駆動信号に応答して第１信号を発生し、センタータップ２３２に与えられる可変電圧駆動信号をシンクし、そして第２の位相ドライバ３４０は、コントローラ４００からの第２駆動信号に応答して第２の信号を交互に発生し、センタータップ２３２に与えられる可変電圧駆動信号をシンクする。本発明のこの特徴により、第１の位相ドライバ３３０からの第１信号と第２の位相ドライバ３４０からの第２信号は、同じく同周波数であって且つ位相が１８０°ずれている。

【００１９】図１及び２は、塗装材料アプリケータ１００とターゲット物体Ｔとの間の高電圧を表す電圧感知信号を発生するために高電圧モジュールの出力２２０に接続された電圧感知モジュール５００を示している。１つの実施形態において、この電圧感知信号は、高電圧モジュールの出力２２０の抵抗性分割回路により発生される第１電圧フィードバック信号に基づく。この目的に適した第１電圧フィードバックの抵抗性分割回路は、参考としてここに取り上げる本発明の譲受人に譲渡されたヒュージ氏の１９８８年５月１７日付けの「電源(Power Supply)」と題する米国特許第４，７４５，５２０号に詳細に開示されている。電圧感知モジュール５００は、シス

テムコントローラ４００に電圧感知信号を与えるためにシステムコントローラ４００に接続される。システムコントローラ４００は、電圧感知信号に応答して制御モジュール３００に制御信号を発生及び供給し、塗装材料アプリケータ１００の高電圧は、システムコントローラ４００からの制御信号に応答して定常動作の間に制御モジュール３００により第１電圧レベルに調整することができる。この第１電圧レベルは、一般に、特定の塗装用途に対して選択されたユーザ定義の電圧レベルであって、ユーザインターフェイス３０においてシステムコントローラ４００に入力されそして可視インジケータ４０に表示される。１つの実施形態において、電圧感知信号は、上記のヒュージ氏の１９８８年５月１７日付けの「電源」と題する米国特許第４，７４５，５２０号に詳細に開示されたように、パルス巾変調器の可変電圧を制御するための制御信号を発生する比較器へ供給される。図２の実施形態では、電圧感知信号は、バッファ２０を経てマイクロプロセッサベースのシステムコントローラ４００へ供給され、そしてシステムコントローラ４００は、それに応答して、パルス巾変調器３１０により発生される可変出力信号を制御するための制御信号を発生し、上記のようにスイッチングレギュレータ３２０を制御する。従って、塗装材料アプリケータ１００の電圧は、塗装材料アプリケータ１００に所望の電圧を与えるように電圧感知信号に応答して動的に増加又は減少される。

【００２０】図１に示された電流感知モジュール６００は、塗装材料アプリケータ１００とターゲット物体Ｔとの間の直流電流（Ｉ）、塗装材料アプリケータとターゲット物体との間の電流変化率（ｄｉ／ｄｔ）、及び塗装材料アプリケータとターゲット物体との間の帯域通過周波数範囲におけるフィルタされた電流ＢＰ（ｉ）のうちの少なくとも１つ以上を表す電流感知信号を発生するために高電圧モジュールの出力２２０に接続される。１つの実施形態において、電流感知信号は、接地点への高電圧モジュールの出力２２０の戻り路と直列な抵抗値により発生される第２の電圧フィードバック信号に基づく。この目的に適した第２の電圧フィードバック抵抗回路は、参考としてここに取り上げる本発明の譲受人に譲渡されたヒュージ氏の１９８８年５月１７日付けの「電源」と題する米国特許第４，７４５，５２０号に詳細に開示されている。本発明のこの特徴によれば、直流電流は、電流感知信号に対応する第２の電圧フィードバック信号のＤＣ成分に比例し、そして電流変化率信号及びフィルタされた電流信号は、以下に述べるように、第２の電圧フィードバック信号から発生される。

【００２１】又、電流感知モジュール６００は、システムコントローラ４００へ電流感知信号を与えるためにシステムコントローラ４００に接続される。システムコントローラ４００は、電流感知信号に応答して制御モジュール３００に制御信号を発生及び供給し、塗装材料アプリケータ１００の高電圧は、システムコントローラ４００からの制御信号に応答して制御モジュール３００により動的に調整可能である。従って、塗装材料アプリケータ１００に送られる高電圧は、電圧感知信号及び電流感知信号の両方に応答して制御される。しかしながら、高電圧を制御する目的のために、電流感知信号の方が電圧感知信号よりも優先順位が高い。というのは、電流感知信号は、一般に、高い電圧を減少することにより防止できる初期の静電気放電を表すからである。図２の実施形態において、電流感知信号は、マイクロプロセッサベースのシステムコントローラ４００に供給され、これは、制御モジュール３００の可変電圧駆動信号を制御するための制御信号を発生するが、これら制御信号は、アナログ回路によって発生されてもよい。

【００２２】電流変化率は、一般に、電流感知信号をサンプリングし、そして最も最近サンプリングされた信号を既にサンプリングされた信号と比較することにより測定される。１つの実施形態において、電流感知信号に対応する第２の電圧フィードバック信号は、参考としてここに取り上げる本発明の譲受人に譲渡されたベントリー氏の１９８０年２月５日付けの「静電塗装システム(Electrostatic Coating System)」と題する米国特許第４，１８７，５２７号に詳細に説明されたように、サンプル・ホールド回路を組み込んだ傾斜検出回路へ供給される。図２の実施形態では、電流感知信号に対応する第２の電圧フィードバック信号がバッファ２２を経てマイクロプロセッサベースのシステムコントローラ４００へ供給される。この構成では、マイクロプロセッサベースのシステムコントローラ４００は、電流感知信号を連続的にサンプリングし、そして最も最近サンプリングされた電流感知信号を既にサンプリングされた電流感知信号と比較し、電流変化率の尺度を得る。１つの実施形態では、システムコントローラ４００は、電流感知信号のＤＣ成分をサンプリングし、電流変化率の尺度を得る。マイクロプロセッサベースのシステムコントローラ４００で達成できる比較的高いサンプリングレートは、電流変化率の尺度を比較的瞬時に与え、これにより、システムコントローラ４００は、塗装材料アプリケータ１００の高電圧をより応答的に制御することができる。この改善された高電圧制御により、システムコントローラ４００は、塗装材料アプリケータの高電圧をディスエイブルする必要のあるレベルまで電流変化率が上昇する前に電流変化率の上昇に応答して塗装材料アプリケータ１００の高電圧を減少し、その結果、以下に詳細に述べるように、一般的に改良された運転効率を得ることができる。

【００２３】帯域通過周波数範囲におけるフィルタされた電流は、一般的に、帯域通過フィルタで電流感知信号をフィルタすることにより測定される。１つの実施形態においては、参考として取り上げるヒュージ氏の米国特許第４，７４５，５２０号に詳細に開示されたように、

電流感知信号に対応する第２のフィードバック電圧信号は、アナログの帯域通過フィルタ回路に供給され、帯域通過周波数範囲におけるフィルタされた電流が発生される。図２の実施形態では、電流感知信号に対応する第２の電圧フィードバック信号は、バッファ２４によりマイクロプロセッサベースのシステムコントローラ４００に接続されたプログラム可能な帯域通過フィルタ５０へ送られ、この帯域通過フィルタ５０は、システムコントローラ４００によりプログラムできる。１つの用途において、帯域通過フィルタの範囲は、約２００Ｈｚを中心周波数として約２０Ｈｚないし約２０００Ｈｚである。より一般的には、周波数範囲はもっと広くても狭くてもよく、そして中心周波数は、特定の用途に基づいて変化する。１つの構成においては、多数の異なる周波数範囲と、それに対応する中心周波数がメモリに記憶され、異なる塗装材料用途において選択されそして使用される。本発明のこの特徴によれば、フィルタ５０の出力信号は、帯域通過周波数範囲におけるフィルタされた電流に対応し、そして塗装材料アプリケータ１００におけるコロナ放電の可能性を示す。システムコントローラ４００は、以下に詳細に述べるように、帯域通過周波数範囲におけるフィルタされた電流の測定レベルに応答して塗装材料アプリケータ１００へ供給される高電圧を制御する。

【００２４】塗装材料アプリケータ１００へ供給される高電圧は、直流電流の増加、電流変化率の増加、及び帯域通過周波数範囲におけるフィルタされた電流の増加の少なくとも１つ以上を表す電流感知信号に応答して、動的に減少することができる。又、塗装材料アプリケータ１００へ供給される高電圧は、直流電流の減少、電流変化率の減少、及び帯域通過周波数範囲におけるフィルタされた電流の減少の少なくとも１つ以上を表す電流感知信号に応答して、制御モジュール３００により動的に増加することができる。

【００２５】図３は、塗装材料アプリケータ１００へ供給される高電圧と、塗装材料アプリケータ１００とターゲット物体Ｔとの間の直流電流との例示的負荷曲線関係を示すグラフである。本発明の１つの特徴によれば、塗装材料アプリケータ１００へ供給される高電圧は、第１の直流電流レベルI_1より上昇する直流電流、第１の電流変化率レベルより増加する電流変化率、及び第１の帯域通過電流レベルより増加する帯域通過周波数範囲におけるフィルタされた電流の少なくとも１つ以上を表す電流感知信号に応答して第１の電圧レベルV_1以下に動的に減少される。又、塗装材料アプリケータの高電圧は、第１の直流電流レベルに向かって減少する直流電流、第１の電流変化率レベルに向かって減少する電流変化率、及び第１の帯域通過電流レベルに向かって減少する帯域通過周波数範囲におけるフィルタされた電流の少なくとも１つを表す電流感知信号に応答して、第１の電圧レベルV_1に向かって動的に増加される。

【００２６】図３に示す本発明の別の特徴によれば、塗装材料アプリケータに供給される高電圧は、直流電流限界I_{max}を越える直流電流、変化率限界を越える電流変化率及び帯域通過フィルタ電流限界を越える帯域通過周波数範囲におけるフィルタされた電流の少なくとも１つ以上を表す電流感知信号に応答してディスエイブルされる。又、塗装材料アプリケータに供給される高電圧は、電圧がある最小値まで減少したときにディスエイブルされてもよい。

【００２７】本発明の別の特徴によれば、システムコントローラ４００は、欠陥状態を生じた電流感知信号成分が指定の時間内に消失した際に、塗装材料アプリケータ１００に供給されるディスエイブルされた電圧をイネーブルするように自動的に試みる。１つの動作モードにおいては、例えば、ディスエイブルされた高電圧は、コロナ放電を表す帯域通過周波数範囲におけるフィルタされた電流のレベルが指定の時間内に消失した際にイネーブルされる。本発明のこの特徴によれば、システムコントローラ４００は、ディスエイブルされた高電圧を手動でリセットしなければならない前に、システムを何回もリセットするよう試みる。

【００２８】システム１０に最初に電力を付与する間及びシステム１０を自動的にリセットする間に、変圧器のセンタータップ２３２に供給される可変電圧駆動信号は、システムコントローラ４００の制御のもとで所定の増加率で第１の電圧レベルに向かってアップ方向に傾斜され即ち増加される。しかしながら、電圧増加率は、放電を表す電流感知信号に応答して減少されてもよくそして最終的にディスエイブルされてもよい。電圧増加率は、一般的に、初期のパワーアップ状態と自動的なシステムリセット状態で同じではなく、自動的なシステムリセット状態では、システムに最初に電力を付与する間に必要とされる以上の迅速な電圧増加が必要とされる。

【００２９】図３のグラフは、実質的にリニアな動作領域を含む電圧と直流電流の関係を示すが、電圧－直流電流の関係は一般的には非リニアである。電圧と電流変化率との間、及び電圧と電流感知信号のフィルタされた電流成分との間にも同様の関係が存在するが、これら各々の電圧－電流関係は一般的に独特のもので、非リニアである。電流変化率及びフィルタされた電流のパラメータは、独特であるが、直流電流パラメータが用途ごとに変化するほどは、用途ごとに変化しない傾向がある。必要とされる直流電流レベルは、例えば、とりわけ、塗装材料の導電率、塗装材料アプリケータの形式、塗装材料アプリケータとターゲット物体との間の距離、並びにターゲット物体のサイズ及び形状を含む静電塗装システムの構成及び特定の用途に関連した多数のファクタに依存している。従って、直流電流レベルは、ユーザが定義する電流レベルであって、特定の塗装用途に対して選択さ

れ、ユーザインターフェイス３０に入力され、そして可視インジケータ４０により表示される。一般に、電圧と電流の種々の関係は、実験で決定されると共に、受け入れられる工業規格を参照することにより決定される。

【００３０】マイクロプロセッサベースのシステムコントローラにおいては、電流感知信号及び電圧感知信号の電流パラメータに対する電圧－電流関係が、一般に、プログラムされたアルゴリズムにより制御される。本発明のこの特徴によれば、アルゴリズムは、特定の静電塗装システム構成又は用途に対して容易に改定又は再プログラムされる。更に、異なる電圧－電流アルゴリズムをもつ多数のプログラムをマイクロプロセッサに関連したメモリに記憶し、特定のシステム構成及び用途に対して所望の電圧－電流アルゴリズムを選択し、静電塗装システムのための実質的に普遍的な高電圧電源を形成することもできる。又、マイクロプロセッサをベースとするシステムコントローラ４００は、システム性能、及び性能に関連したデータの記憶、特に、不揮発性メモリ６０の欠陥状態を監視することができ、これを後で分析して、電圧制御アルゴリズム改定のベースとすることができる。シリアル入力／出力ポート７２によりシステムコントローラに接続されたコンピュータ７０は、システムコントローラ４００にアルゴリズムをダウンロードしたりシステムコントローラのメモリからデータをアップロードしたりするのに使用できる。

【００３１】上記電流パラメータを表す電流感知信号に応答して塗装材料アプリケータ１００に供給される高電圧を動的に制御することは、電流パラメータが切迫した放電を示す比較的広範囲の状態を表し、感度を高めることになるので、静電塗装システムの放電を防止する上で顕著な進歩及び改善をもたらす。

【００３２】本発明の別の特徴によれば、高電圧モジュール２００の動作効率が高められ、塗装材料アプリケータ１００とターゲット物体との間の放電が防止される。図１は、位相感知信号を発生するために高電圧モジュールの出力２２０に接続された位相感知モジュール７００を示している。この位相感知モジュール７００は、システムコントローラ４００に位相感知信号を与えるためにシステムコントローラ４００にも接続される。本発明のこの特徴によれば、システムコントローラ４００は、第１及び第２の位相ドライバ３３０及び３４０からの第１及び第２の信号の駆動周波数を９０° の位相ずれで高電圧変圧器２３０の共振周波数に実質的に整合させ、変圧器の出力の電圧信号を最大にする。変圧器の出力の位相感知信号を発生する回路、及び位相及び周波数を制御する回路は、参考としてここに取り上げる本発明の譲受人に譲渡されたヒュージ氏等の１９９２年１０月２７日付けの「高電圧電源制御システム(High Voltage Power Supply Control System)」と題する米国特許第５，１５９，５４４号に詳細に開示されている。第１及び第２の位相ドライバ３３０及び３４０の第１及び第２の駆動信号の駆動周波数及び位相は、ターゲット物体Ｔが塗装材料アプリケータ１００に近づいたり離れたりするときに変化する傾向のある高電圧変圧器２３０の共振周波数に整合するように動的に制御される。変圧器２３０をその共振周波数で動作すると、変圧器の出力に最大電圧が発生し、従って、塗装材料アプリケータ１００に供給される電圧の予期せぬ増加が生じて放電を招くおそれを低減する。図２の実施形態では、位相フィードバック信号がバッファ２４を経てマイクロプロセッサベースのシステムコントローラ４００へ供給され、そしてシステムコントローラ４００は、第１及び第２の位相ドライバ３３０及び３４０からの第１及び第２信号の駆動周波数の周波数を、高電圧変圧器２３０の共振周波数に整合するように制御する。１つの実施形態では、高電圧変圧器２３０が普遍的な巻線型変圧器であり、駆動周波数は、約４５ｋＨｚないし約１１０ｋＨｚの間で変化し、この周波数範囲は、異なる用途及びシステム構成に対して更に広くても狭くてもよい。

【００３３】本発明の別の特徴によれば、高電圧変圧器２３０の動作効率は、変圧器２３０に供給される制御モジュール３００からの可変電圧駆動信号を減少して塗装材料アプリケータ１００へ送られる高電圧を発生することにより更に最適化される。又、これは、高電圧モジュールにより発生される熱も減少し、これは、手持ち式の塗装ガン及び小型の塗装材料付与装置において特に重要な事柄である。又、高電圧モジュール２００の熱を減少することは、電圧整流器及びマルチプライヤのストレスも減少し、これは、動作寿命を延ばすことになる。本発明のこの特徴によれば、電圧駆動感知モジュール８００が、電圧駆動感知信号を発生するために制御モジュール３００に接続される。この電圧駆動感知信号は、制御モジュール３００により発生された可変電圧駆動信号において抵抗性分割器により発生される。又、電圧駆動感知モジュール８００は、システムコントローラ４００に電圧駆動感知信号を与えるためにシステムコントローラ４００にも接続され、システムコントローラ４００は、第１及び第２の位相ドライバ３３０及び３４０からの第１及び第２の信号の駆動周波数をスイープ即ち変化させ、制御モジュール３００からの可変電圧駆動信号が最小となる駆動周波数を決定する。従って、駆動周波数は、高電圧変圧器２３０へ送られる可変電圧が、塗装材料アプリケータ１００へ送られる所望の高電圧に対して最小となるところの周波数へ変化する。変圧器２３０の効率を高めるこの特徴は、単独で使用することもできるし、上記の周波数整合及び位相ずれ特徴と組み合わせて使用することもできるが、変圧器２３０に供給される可変電圧を最小にする努力において変圧器２３０の共振周波数に対して制限された範囲内で駆動周波数を変化させ、駆動周波数及び共振周波数の整合を妥協するという制約を伴

う。

【００３４】本発明の別の特徴によれば、高電圧変圧器２３０の動作効率は、第１及び第２の位相ドライバ３３０及び３４０の第１及び第２の信号間に遅延を与えて、極性反転の前に可変電圧駆動信号により変圧器に誘起される電界の崩壊を許すことにより、更に最適化される。これは、変圧器のセンタータップ２３２へ供給される可変電圧駆動信号を減少すると共に、変圧器により発生される熱を減少する。図４は、変圧器のセンタータップ２３２へ供給される可変電圧駆動信号を交互にシンクするために第１及び第２の位相ドライバ３３０及び３４０を駆動する相補的な第１及び第２の位相駆動信号間の遅延即ちデッドスペースを示す。本発明の１つの特徴によれば、位相駆動信号間の遅延は、固定遅延時間である。別の実施形態では、所望の出力電圧に対しスイッチングレギュレータ３２０からの電圧駆動感知信号に応答して可変電圧駆動信号が最小にされるところの遅延時間を決定するために遅延時間が小さな範囲にわたって変更される。高電圧変圧器２３０の効率を高めるこの方法は、単独で使用されてもよいし、又は上記した本発明の他の効率改善特徴の１つ以上と組み合わせて使用されてもよい。

【００３５】以上の説明から、当業者であれば、本発明の最良の態様と現在考えられるものを実施しそして利用することができるであろうが、ここに述べた特定の実施形態の精神及び範囲内で種々の変更、組合せ及び等効物が容易に理解されよう。それ故、本発明は、上記の特定の実施形態によって限定されるものではなく、特許請求の範囲のみにより限定されるものとする。

＊【図面の簡単な説明】

【図１】本発明の実施形態による静電塗装システムのブロック図である。

【図２】本発明の実施形態によるマイクロプロセッサベースの静電塗装システムのブロック図である。

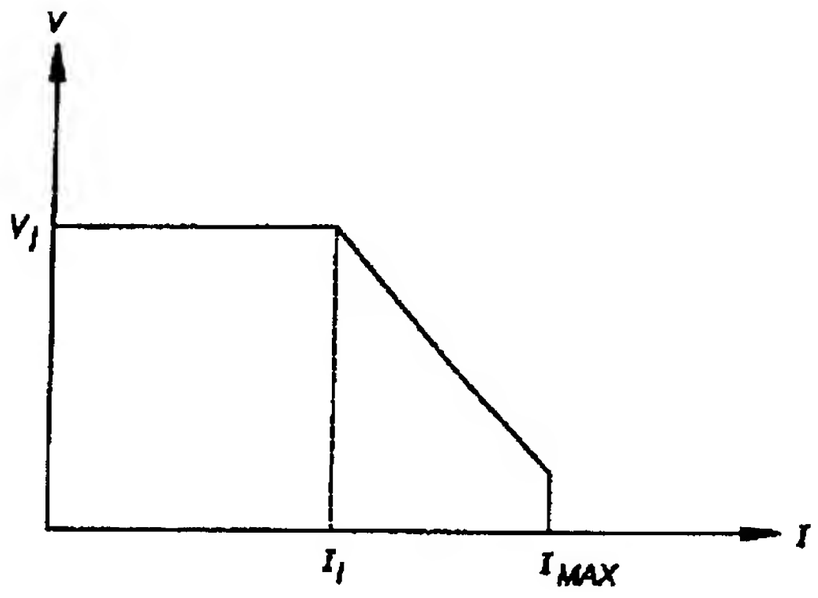
【図３】本発明による静電塗装システムの負荷電圧対電流の関係を示すグラフである。

【図４】対応する第１及び第２の位相ドライバによって発生された第１及び第２の駆動信号を表す相補的な第１及び第２の波形を示す図である。

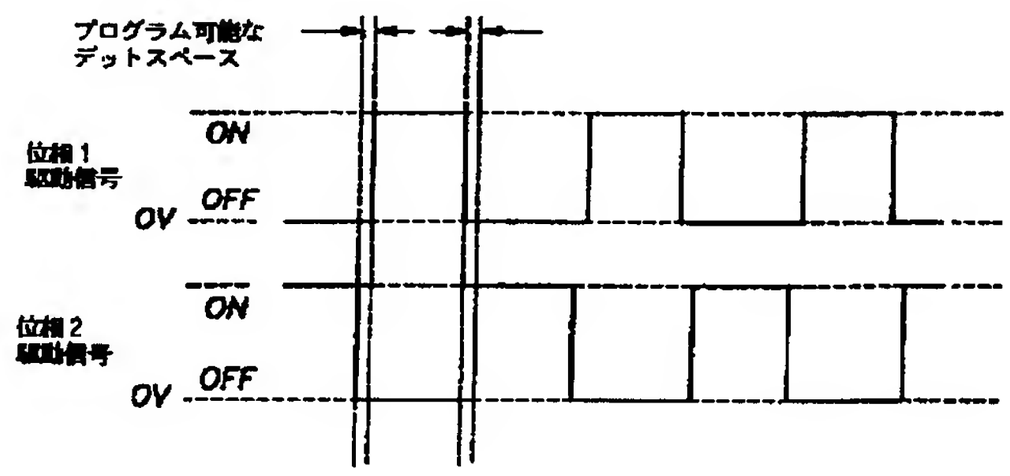
【符号の説明】

１０	静電塗装システム
１００	塗装材料アプリケータ
２００	高電圧モジュール
２１０	入力
２２０	出力
２３０	高電圧変圧器
２３２	センタータップ
２４０	高電圧整流器・マルチプライヤ回路
３００	制御モジュール
３１０	パルス巾変調器
３２０	スイッチングレギュレータ
３３０	第１位相ドライバ
３４０	第２位相ドライバ
４００	システムコントローラ
５００	電圧感知モジュール
６００	電流感知モジュール
７００	位相感知モジュール
８００	電圧駆動感知モジュール

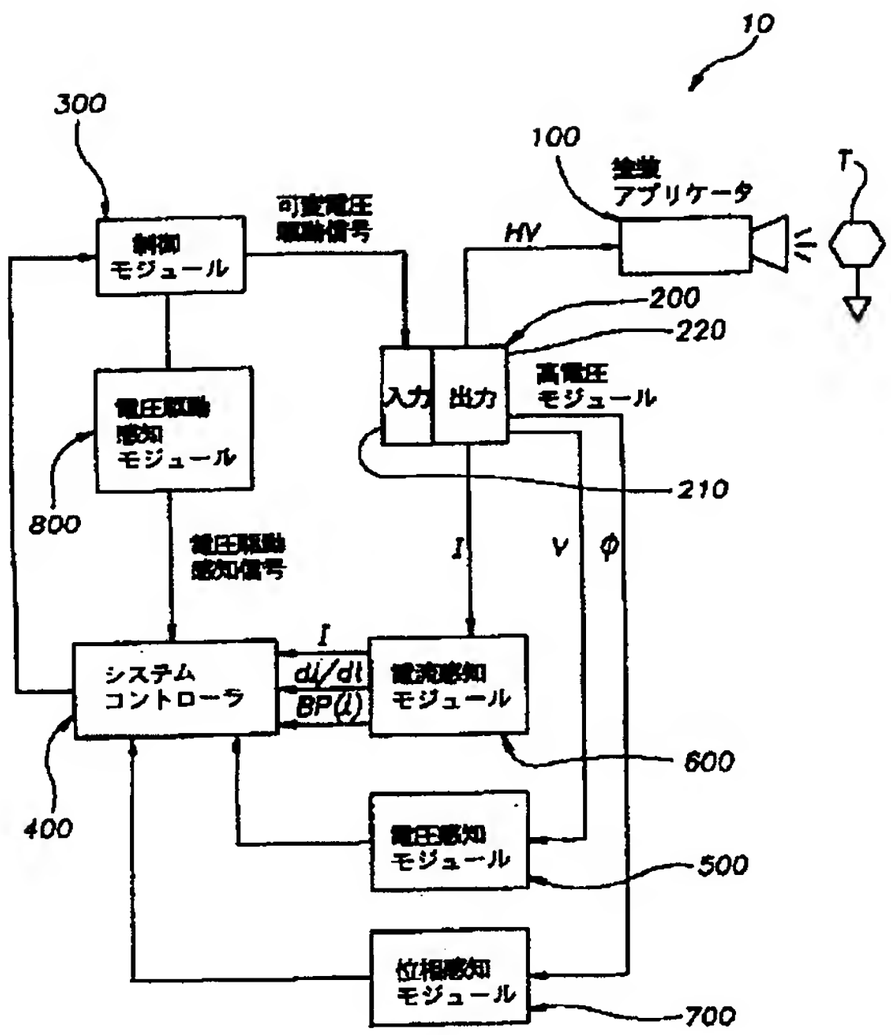
【図３】



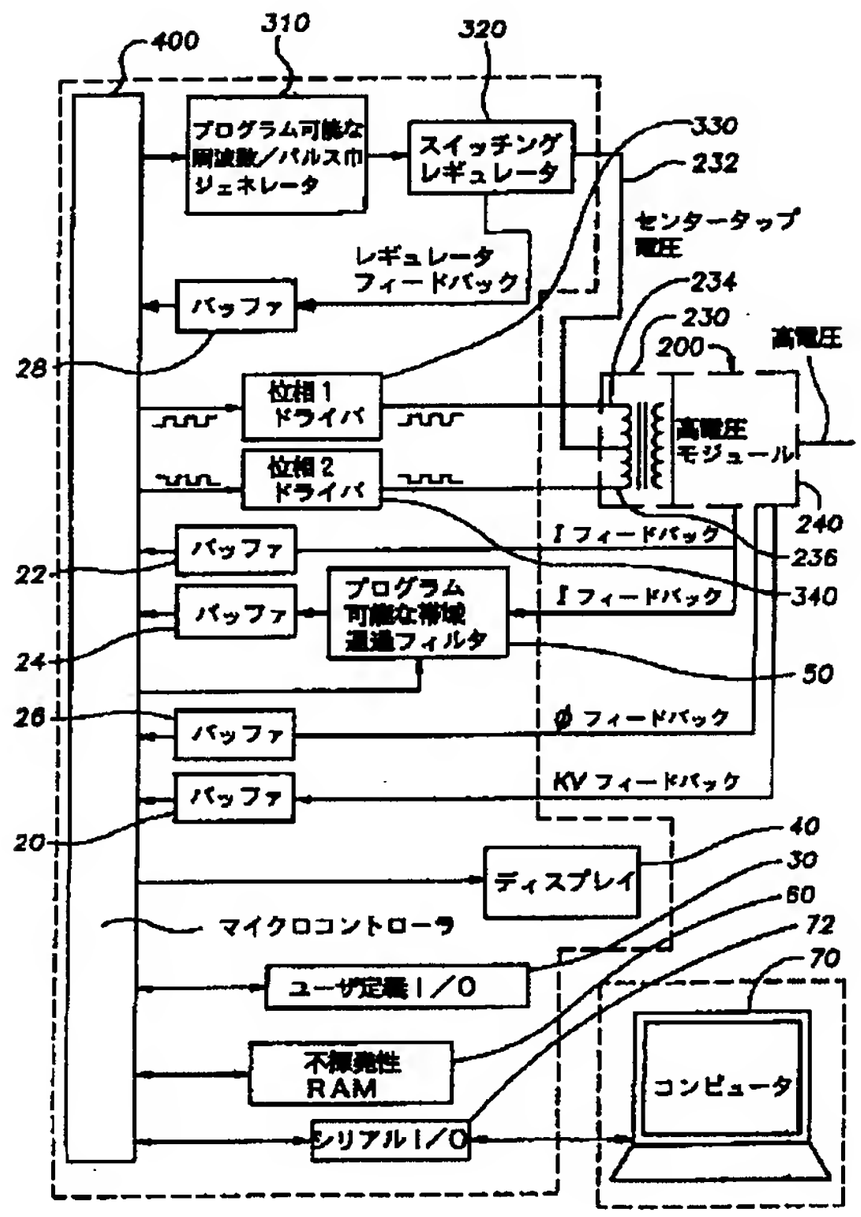
【図４】



【図１】


10
300
100
塗装
アプリケータ
T
可変電圧
駆動信号
制御
モジュール
HV
200
220
入力
出力
高電圧
モジュール
電圧駆動
感知
モジュール
800
210
電圧駆動
感知信号
I
V
φ
I
dI/dt
BP(I)
システム
コントローラ
電流感知
モジュール
600
400
電圧感知
モジュール
500
位相感知
モジュール
700

【図２】


400
310
320
プログラム可能な
周波数／パルス巾
ジェネレータ
スイッチング
レギュレータ
330
232
センタータップ
電圧
レギュレータ
フィードバック
バッファ
234
230
200
高電圧
28
位相1
ドライバ
高電圧
モジュール
位相2
ドライバ
240
I フィードバック
236
22
バッファ
340
バッファ
プログラム
可能な帯域
通過フィルタ
I フィードバック
24
50
26
バッファ
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